TAMPERE UNIVERSITY OF TECHNOLOGY

PETRA PURHONEN

THE METHODS OF OPERATIONS MANAGEMENT IN THE TOOL MAKING INDUSTRY

Master Thesis

Examiner: Professor Asko Riitahuhta
Examiner and topic approved in the meeting of the Faculty of Automation, Mechanical and Materials Engineering
August 17th 2011

ABSTRACT

TAMPERE UNIVERSITY OF TECHNOLOGY
Master's Degree Programme in Mechanical Engineering
PURHONEN, PETRA: The methods of operations management in the tool making industry
Master of Science Thesis, 68 pages, 2 Appendix pages
October 2011
Major: Production Engineering
Examiner: Professor Asko Riitahuhta
Keywords: strategy, business model, operations, analyzing methods, tool making industry

This thesis gathers methods, tools, and techniques suitable for tool makers to analyze, manage, implement, and develop their operations. It has been written for a research group in the tool making laboratory (Werkzeugmaschinenlabor) in Rheinisch-Westfaelische Technische Hochschule Aachen (RWTH Aachen). The goal of this research was to find some ideas about the areas where the research group could develop a new analyzing method for tool making industry.

The theoretic background for this research report forms from strategic management and planning and from the business model theory of Lechner and Müller-Stewens (2005), chosen by the research group. The main target of this research, operationalizing, is always depending on strategic choices that have been made in a company.

A sample of methods, tools and techniques for analyzing, developing, implementing and managing operations are described and classified into different fields of operations. From among these methods, tools and techniques some areas rouse up as more meaningful for tool makers. They are presented as suggestions for future research for the research group at the end of this report. These suggestions relate to the skills of the human resources, service functions, and co-operation platforms with which the European tool makers try to compete in the global markets.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
Konetekniikan koulutusohjelma
PURHONEN, PETRA: Operationaalisen johtamisen metodit työstökoneteollisuudessa
Diplomityö, 68 sivua, 2 liitesivua
Lokakuu 2011
Pääaine: Tuotantotekniikka
Tarkastaja: professori Asko Riitahuhta
Avainsanat: strategia, liiketoimintamalli, operaatiot, analyysimenetelmät, työstökoneteollisuus

Tähän työhön on kerätty työstökoneteollisuudenoperaatioiden analysointiin, johtamiseen, implementointiin sekä kehittämiseen soveltuvia metodeja, tekniikoita ja työkaluja. Työ on kirjoitettu tutkimusryhmälle Aachenin Teknillisen Korkeakoulun työstökonelaboratorioon (Werkzeugmaschinenlabor in Rheinisch-Westfaelische Technische Hochschule, RWTH, Aachen). Tutkimuksen tavoite oli löytää mahdollisia alueita, joihin tutkimusryhmä voisi kehittää uuden, työstökoneteollisuuteen soveltuvan, analyysimetodin.

Strateginen johtaminen ja suunnittelu sekä tutkimusryhmän valitsema Lechnerin ja Müller-Stewensin liiketoimintamalli (2005) luovat teoreettisen pohjan tutkimukselle. Tutkimuksen pääpaino on operationaallistamisessa, johon yrityksessä tehdyt strategiset valinnat aina vaikuttavat.

Metodit, tekniikat ja työkalut operaatioiden analysointiin, johtamiseen, implementointiin sekä kehittämiseen on kuvattu sekä jaoteltu operaatioiden eri osa-alueille. Näiden metodien, tekniikoiden ja työkalujen joukosta nousi tutkimuksen edetessä esiin joitain työstökoneteollisuudelle tärkeitä asioita, jotka on esitetty tulevaisuuden tutkimusehdotuksina tutkimusryhmälle raportin lopussa. Nämä liittyvät henkilöstön osaamiseen, huolto- ja palvelutoimintoihin sekä yritysyhteistyöhön, jolla eurooppalaiset työstökoneteollisuusyritykset yrittävät vastata globaaliin kilpailuun.

PREFACE

I came to Germany in September 2010 to learn to speak the language I had studied for more than ten years and to be closer to my love. In the beginning of 2011 I realized that I could write my master thesis in Germany. I sent mail to RWTH Aachen and visited Bastian Schittny in Aachen after receiving a positive answer, and got an assignment. I moved to Aachen in the beginning of April 2011 and started my research. I would like to thank Bastian for giving me this opportunity and the whole research group for this interesting project. I hope it continues successfully in the future as well.

During my research and writing project my mum has been my biggest supporter and motivator. She always believed in me and made me believe in myself and I thank her for that. My parents also visited me in Germany several times and that way eased my homesickness and I'm grateful for that as well. I also want to thank my friends in Finland and in Germany, and my boyfriend for supporting me and for believing in me even more than I did at some points. And last but not least I want to thank my always supportive brother, who made it possible for me to live in another country and still have a relationship to my godson with weekly talks via Skype. Without that I could not have stayed so long.

CONTENTS

TERMS AND DEFINITIONS

BM	*Business model* describes the logic for making money in the current and changing business environment.
Strategy	*Strategy* is a direction of an organization over the long-term.
Operationalization	Putting business model into operations.
PWP/job shop	"*Plant Within a Plant*" or a *job shop* is an operations system where there are a number of work centers in a plant instead of an assembly line.
SBU	*Strategic business unit* is an autonomous unit inside a company, for example a division or a brand.
SME	SME is a *small or medium size enterprise*.
COQ	*Cost of quality* is a quality philosophy that divides quality costs into four categories.
TQM	*Total quality management* is a quality philosophy addressing quality management in all aspects of a business.
QFD	*Quality function deployment* is a tool of TQM.
MTBF	*Mean time between failures* tells when the next failure is likely to happen and is used in planning maintenance.
JIT	*Just-in-time* philosophy means designing systems that deliver products or services just when they are needed.
MTO	The companies that have "*a make to order*" strategy base their demand on customer orders.

1 INTRODUCTION

Toolmakers manufacture the industrial tools used by companies that mass-produce consumer goods in factories. These tools are not simple like hammers or screw drivers, the tools are complicated machines and a toolmaker needs special skills in metals and other materials, and engineering to produce them. (Charles Sturt University) This thesis has been written in the point of view of the tool making industry.

This research report is a part of a bigger research project the in tool making laboratory (Werkzeugmaschinenlabor) in Rheinisch-Westfaelische Technische Hochschule Aachen (RWTH Aachen). The goal of the research project is to create a new method for analyzing business or a certain part of it in companies in the tool making industry. Other research about the tool making industry have been made earlier in the tool making laboratory of RWTH as well.

The basis for the whole project and for this thesis is shown in picture 1.1. Value creation configuration of a toolmaker consists of three different blocks that are tightly tied together: strategy, business model and operationalization. Value creation configuration is in consistent interaction with the changing markets and environment and has to be able to adapt to the changes. The main goal for this thesis is to find methods and techniques to analyze and develop the operationalization block, where middle managers are working and to define the gap between the existing methods and the ones still waiting to be created. The two other blocks work as a theoretic background for the thesis. The strategic management and the top managers are not the target of this research.

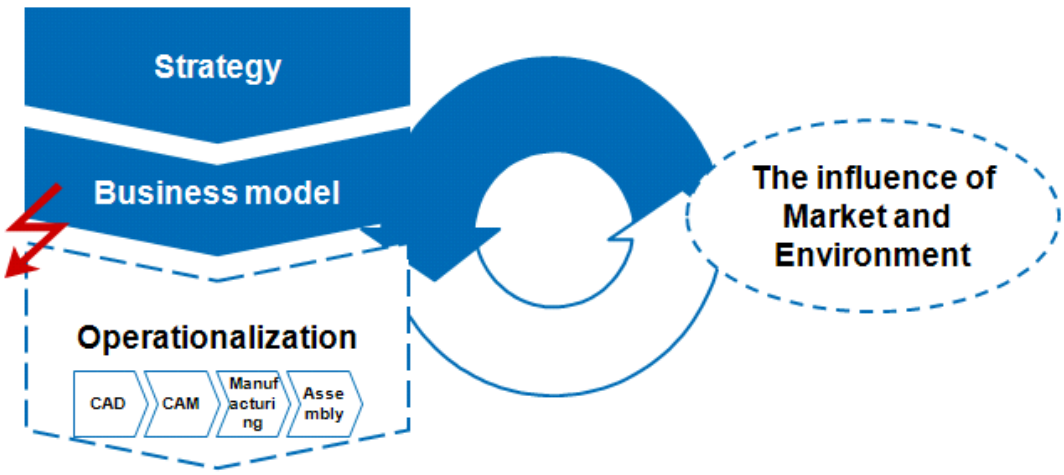


Image 1.1 *Value creation of a toolmaker (Schittny 2011)*

The second chapter will open the reasons why this thesis was written and how the research was conducted. The third chapter presents the tool making industry and tells about its general and special features. In the fourth chapter this thesis will concentrate on how to analyze, plan and implement a company's strategy. The main points of business analysis are presented as well. The fourth chapter will also discuss how to choose the right business model to complement the chosen strategy and how to change the business model. Basically the fourth chapter gives the theoretical background knowledge needed to understand the final two chapters. In these chapters, five and six, the models, tools, and techniques for analyzing, developing, managing and improving operations are presented and the suggestions for the research group for the future research are reflected on. Chapters five and six answer the research questions. The reliability analysis will end the research report.

2 RESEARCH METHODS AND QUESTIONS

This thesis researches literature and provides information for the research group at the tool making laboratory of RWTH Aachen. In this chapter the research questions and the methods used for finding the answers are explained. In the beginning there were much more questions, but during the research project the questions presented in chapter 2.1 became the ones worth finding answers for. The methods also formed during the research process. How this happened, is described in chapter 2.2.

2.1 The research questions

The research questions are:

1. What kind of methods are available and used for analyzing, implementing, managing and improving operations in the tool making industry?
2. For which business area should a new method be developed in the tool making industry?

2.2 The research methods

I started working with the research group at RTWH in the beginning of May. The group was led by Bastian Schittny (Lehrstuhl für Produktionssystematik) and the other three members were students at RWTH. Every time we met during the first two months the research goals begun to take shape. In a project where a group is trying to create something new, the goals and tasks are often unclear in the beginning, and so it was in our project. We tried to set the goals by discussing the topic with different techniques. In April we had a brainstorming session, where we thought about analyzing methods that we already knew and wrote them on a wall. We drew maps of different analyzing scenarios and discussed where the gap could be found and what kind of new method the group could come up with. My tasks formed into the research questions explained above in chapter 2.1 (The research questions).

Identical terms are often used in literature for different things. One job for the research group was to synchronize the terms that we were going to use, like value creation configuration which is explained in chapter one. Another challenge concerning the terms was that this thesis is written in English and the other group members wrote in German, so we had to translate the crucial terms and clarify them in two languages. The mother tongue of the writer of this report is Finnish.

The research is done by examining the existing methods, tools, and techniques in literature. In the early stages of the research it came clear that the given research task was

huge and that there are a lot of methods for analyzing different things in business. Analyzing the financial aspects was defined out from the research and that's why it is only explained shortly in the text. The models for analyzing the strategic level have been defined out. However, the strategic level forms the theoretic foundation for the research about the methods, tools, and techniques for the operational level in which the research and this report is concentrating. Chapter five of the research report contains a sample of operationalizing as an answer for the first research question: the methods tools and techniques used in operationalization.

Methods, tools, and techniques suitable for tool makers have been picked out from research reports, literature, and articles. They are classified by combining classifications of Hill (2000) and Heizer& Render (1999). The classifications form the headlines in chapter 5.3 (Theories and techniques for managing, analyzing and developing operations for tool makers). Methods found from other studies have been situated in this classification. Analysis of the contents was used in the classification of the methods, tools, and techniques.

The second research question was concerning finding the gap. During the writing process and the analysis of the contents some management point of views started to seem especially important for the tool making industry. These points of views are presented as future research possibilities and as possible gaps for developing new methods in chapter six. All of the methods, tools and techniques were placed in an excel chart for examining the possible place of the gap. The excel chart is discussed in chapter six.

During the writing and analyzing process the writer of this research report met some of the group members a couple of times. One meeting occurred in June with one of the other students and it formed into a motivation speech from both sides. In June the writer also met the group leader two times for a short discussion about the theme and for getting new literature. The final meeting held place at the end of July. The writer was looking forward to get some feedback, but sadly did not get more than an ok.

Now that the goals and research methods of this thesis have been clarified, it is time to talk about the tool making industry. The tool making industry was also researched by researching literature about it and as expected, most of this literature was created in the RWTH Aachen. The goal of chapter 3 (The tool making industry) is to give readers a comprehensive picture about the tool making industry and its special features.

3 THE TOOLMAKING INDUSTRY

Tool makers produce the tools used in manufacturing processes. The tools can be used to cut, shape and form metal and other materials or they can be jigs and fixtures that hold metal while it is bored, stamped, or drilled. The machines are being used to produce the products we use in everyday life such as clothes, food, or furniture or even parts of an aircraft. Tool makers design, produce and develop the tools themselves and also repair worn or damaged tools. In the literature die making and tool making are often discussed together because of their similarities. Many tool making companies produce dies as well and the workers can switch between die making and tool making. Die makers construct metal forms used to shape metal in stamping and forging operations and make metal molds for die-casting and for molding composite materials, ceramics and plastic. (United States Department of Labor 2010-11)In this chapter the term toolmaker is used for the tool making companies as well as for employees actually making the tools.

3.1 The current state of the industry

In Europe tool makers are usually small or medium size enterprises (SMEs) managed by their owners. They are locally focused, but also deliver globally. Big global tool makers do not yet exist. Because of all the rules and regulations in Europe, it is hard for the toolmakers to compete with the eastern competition. Also the lack of flexibility and risk taking is preventing tool makers from becoming real global players. But some changes in the industry can be seen. The competition has intensified during the last years, because of the smaller volumes and greater product varieties. The tool making industry that used to be centered in Europe is now moving east to find lower costs. Also the eastern competition is catching up making more and more high-end tools that can be compared with tools made in Europe. (Schuh et al. 2010)

Tool-making industry is strongly linked to every other producing industry. The quality of end products depends on the manufacturing quality of the production tools. Also production time and costs are defined partly by the tool makers; the abilities of a tool influence every start of production, set-up and cycle times. How well the tools are integrated in the existing systems of a company is important too, because they all have to function together. (Schuh et al. 2010 according to Schuh et al. 2009)

The tool making business is order based and its deliveries depend on technical and technological innovations, solutions and tools. Sometimes it can happen that an order cannot be produced with the technologies available in the company. Some technologies are so expensive and special that there are only a few companies in the world mastering

them. There is a need for sharing capacities. Cheap labor force in China and the fast developing eastern countries also motivate western tool makers to form clusters in order to improve the ability to compete. Alliances in Europe have been formed between SMEs, research institutes, educational institutions, and tool-shops. Some of the alliances are even financially supported by governments or local communities. In the future the alliances can develop further with collaborative design, collaborative technology planning, and distributed manufacturing. (Auerbach 2006)

The current trend in many industries is to go closer to the customer, offering more services with the product and creating complete packages. This is starting to show also in the tool making industry. Traditionally toolmakers have not had adequate interfaces with their customers, partly because most of the customer companies are far away. There can be language barriers and cultural differences. Due to the distance, travel cost, travel time, and service expenses are commonly higher. The reaction times in case of malfunctions can grow too long, if the tool maker has to travel long to reach the customer. Schuh et al. (2010) presented collaboration platforms as a solution to all of these problems. Collaboration platforms are web-based solutions that enable European tool makers to offer services through local service partners all over the world. These partners have the language skills and cultural background knowledge needed for making business in different parts of the world, and can reduce the reaction times to service requests.

Changing markets are setting other challenges to the tool making industry. Automotive industry is one of the biggest users of tools and molds made by tool makers; tooling is especially needed in producing motors and transmissions. The rising trend of electric cars is forcing the tool makers to think of other market possibilities, because if combustion engines were replaced by electric motors, the demand of certain type of tools would drop dramatically. New models of electric and hybrid cars are presented to the markets constantly, but tool makers still have some time to adjust, as it has been forecasted that even in 2030 90 percent of the cars still have combustion engines. The development of pharmaceutical companies is also a significant factor for tool makers. In Germany alone the industry employs 170 000 people. If a tool maker wants to have pharmaceutical companies as customers, it has to develop to master even more accurate tooling and new techniques. (Hämäläinen 2010) Also the aging population is creating a challenge of finding skilled employees to the tool making industry. At least in Finland, the large age groups are about to retire and it is going to be hard to find enough new employees with the needed work experience.

3.2 The nature of work

Employees actually making the tools in tool making companies are one of the most highly skilled and best paid production workers. Many employers have difficulties finding qualified workers, because it takes about four to five years of classroom education and practical work to become one. This is because they have to master a number of

skills like using different machine tools and measuring instruments, have the knowledge in machining properties, such as hardness and heat tolerance of a wide range of materials and also have the knowledge in mathematics and blueprint reading. In fact tool makers are considered as highly skilled, specialized machinists crafting individual, durable and complex machine tools. (United States Department of Labor 2010-11)

The work days of tool makers do not necessarily consist only from building tools. They can also take part in the designing process. A tool maker or a group of them can visit the customer's production so they are able to design a tool that fits to its surroundings. Often it is the engineers that do the design job, but in designing complex machining tools engineers might need the knowledge of the tool makers to come up with a design that that can be manufactured and used. (United States Department of Labor 2010-11)

3.3 A typical layout for tool makers

In operations systems there are two extreme ends: mass production and "Plant within a Plant" (PWP) or a job shop. (Huckman 2009) A job shop is a typical operation system and layout for tool makers. A job shop means that there are no assembly lines and that all the products are customized. The manufacturing hall is divided into job shops and every job shop provides one function such as edging or grinding. This brings the needed flexibility for manufacturing products for special customer orders. The work of one job shop is based on the demand of the others. Job shop production demands superior scheduling and controlling, because there is no steady stream of products but a bunch of individual projects in production. Large inventories of parts and tools are needed, but on the other hand inventories for ready products are not needed, because the production is based on customer orders. Summers calls operation strategy in job shops demand-flow manufacturing. It brings the company benefits also in floor space, rework and price. (Summers 1998, p. 10-12)

Layout decisions are important, because layout affects a company's long-term operational efficiency by affecting capacity, flexibility, processes, cost, and quality of work life, customer contact, and image. In designing layout, higher utilization of space, equipment and people should be achieved. Also, flow of information, materials and people can be improved with layout design. And whatever the layout is, it has to be flexible, because it will need to change at some point. That will be required by product, process or volume changes. (Heizer& Render 1999, p. 322)

3.4 Managing tool making

Huckman (2009) recognizes three challenges in designing and managing job shop systems: establishing objectives, setting boundaries, and managing interaction. Companies can establish objectives for some key units and get them focused and to respond to specific opportunities and threats, but the problem is that the rest of the units are left drift-

ing. It can be hard to set boundaries between different job shops; how and how much should the units communicate with each other? Also managing interaction can be challenging, because some units can have more leaders who actively lobby resources for their units and this way other units get less resources. This can lead to skirmish between units. Luckily, Huckman (2009) also gives advice on how to deal with these problems: managers should make sure that every unit has clear and distinct objectives and that every unit supports the strategy of the company. If this, however, is not the case with some units, spinning them off or ending them are possibilities that should be considered. All the units should know what the objectives for the other units are as well. This way the employees understand decisions better, even when the decision do not favor their own units. The boundaries between units should be porous, so that it is possible to share assets or services. Also positive knowledge transfer should be enabled. It can result to increased productivity due to the competition between units. Negative knowledge transfer can lead to quibbling, so the attitudes should be kept positive. Clear rules of how the resources are shared need to be established to avoid fighting over them. Finally, performance goals should be set individually to each unit.

One part of a complete tool making process is to manage that the tool gets installed right and that the employees in the customer company learn how to use it. This can be hard and take some time for many reasons. In the summer of 2006, the writer of this research report was working for a company in the food industry in Finland. At the beginning of the summer, a new production line combined with a new scaling system was installed in the working station. The tool makers and engineers installing it and telling the workers how to use it spoke only Swedish and English, and the writer was the only one there with good language skills. It has to be considered that the people actually using the tool might not have high education and need user faces that are easy to understand, meaning more than just the right language. More problems appeared when minced meat started to run through the scale. Grease got stuck in the scale and the end products came out weighing too little. A conclusion from the writer's experiences is that a tool maker has to understand also the industry where the tool is going to be used and get to know the processes of the customer company. Collaboration platforms discussed in the previous chapter are one solution to the problems at the moment of delivery and after that, but understanding the different aspects and processes of the customer company is the key to preventing problems beforehand.

3.5 Summary

The goal of this chapter was to get a basic understanding about the tool making industry. Tool makers manufacture complicated tools needed for production in other industries. The tool making industry depends on impulses from its customer industries, new technical and technological innovations, and multi-skilled employees. A typical layout for a tool maker is called job shop and managing it has some typical challenges. The trend of going closer to customer can be seen also in the tool making industry. European

tool makers are trying to fight this challenge by networking or forming platforms, on which they can co-operate.

4 FINDING THE RIGHT STRATEGY AND BUSINESS MODEL AND HOW TO KEEP THEM UPDATED

Value creation configuration, explained in chapter 1 consists of three blocks: strategy, business model and operationalizing. A company needs all these three blocks to succeed and this chapter concentrates on the two first blocks which give the theoretic background for the research about the methods suitable for operations. Chapter 4.1 tells about the forces that shape the strategy, about strategic positioning and how to execute and analyze a strategy. It also presents a method called balanced scorecard. Business analysis is discussed in chapter 4.2, because it is important to understand that a whole business analysis includes more than just the traditional financial analysis. Business model, how it is created, and how to change it, is explained in chapter 4.3.

4.1 Strategy

Strategy means making important decisions of what a company does and maybe even more important; what a company does *not* do (Porter 1996). It is a long-term plan of where the company is going. A strategy for a tool maker could be for example "to be the highest-end producer of steel-cutting machinery in Europe in three years."Business model and operations would then be designed so that they would aim at achieving this strategy. However, it is possible that the strategy changes during those three years. Changes in the environment force the operations in having flexibility and the business model in having a change model. But sometimes the changes can make it necessary for the strategy to change. Porter's five forces (4.1.1) help a company understand the industry where it is competing, which is essential for strategic positioning (4.1.2)

An innovative product, excellent strategy, or a new technology can raise a company to compete with the best of the industry, but only a firm execution of the strategy will keep it there (Neilson et al. 2008). Chapter 4.1.3 concentrates on execution of strategy and in chapter 4.1.4 the balanced scorecard and how to use it in strategic management is presented.

4.1.1 Porter's five competitive forces that shape strategy

In 1979 Michael Porter introduced five competitive forces that explain why industry profitability is what it is. The purpose of the forces is to remind companies that competition consist of much more than just the direct competitors that already exist in the mar-

kets. The structure and nature of competition in the industry is defined by these forces. If the forces are intense, it is less likely for a company to earn great profits and on the contrary if the forces are benign, many companies are profitable. Understanding the five forces and the structure of the industry is also essential to strategic positioning. (See 4.1)

The five competitive forces (Porter 1979) can be seen in picture 4.1. *The threat of entry* depends on how high the barriers are to enter and on what kind of reactions the entering companies can expect from already existing players. If the barriers to enter are low, the threat of entries is high. However, it is not the actual amount of new entries that keep the profitability low; it is the threat of them.

Picture 4.1 *the Five Forces That Shape Industry Competition (Porter 2008)*

When *the power of suppliers* is extremely strong, it can suck the profitability out of an industry that fails to pass on the increasing costs into its own prices. A supplier or a group of suppliers can be powerful, if it is the only group offering some service or product, if the supplier/supplier group does not depend only on one industry on its revenues and is not afraid to squeeze maximum profits from each industry, or if the supplier/supplier group is more concentrated than the industry that it is selling to. On the other side of the coin is *the power of buyers*. A powerful buyer can bargain the prices down or drive up the costs by demanding better quality or more services at the expense of the industry. A customer group has the power to do this, for example, if there are only a few buyers, if the products of an industry are not differentiated, or if the buyers do not face switching costs in changing vendors. The fourth force is *the threat of substitutes*. Substitutes perform the desired function by different means. For example, e-mail is a substitute for traditional post. Possible substitutes can be hard to discover, because the technologies for them might not yet exist or substitutes can also come from a different in-

dustry. For a graduation gift; a trip to New York or a set of tableware can be substitutes. The threat of substitutes is high if the customer's cost of switching is low or if the substitute offers an attractive price-performance trade-off to the product. In the middle of it all is *the rivalry between existing competitors*. The intensity of competition and the basis on which the companies compete affect how much the rivalry pulls down the profits of an industry. The intensity is high, for example, if the barriers to exit are high, if industry growth is slow or if there are a lot of equal competitors. The base for competition can be price, product features, supporting services, delivery time, brand image etc. In the worst case scenario companies are only competing with price, in which case the profits go straight to customers. In best case scenario rivalry leads to improved processes and profits and also to higher barriers to enter the industry. For more information on Porter's five forces, see Porter 1979.

4.1.2 Strategic positioning

According to Porter (1996) the goal of every company is to deliver value to its customers. One can be better than its competitor by delivering greater value to customers, or by delivering same value with lower cost, or by doing both. Strategic positioning means performing different activities than competitors or similar activities in different ways, it is a strategic choice. Without strategic positioning every company in the same field would be doing the same thing and there would not be a need for strategy. Competitive advantage would be achieved only with operational effectiveness and it would be easy to copy. Operational effectiveness means performing similar activities better. The goal of strategy is to achieve a lasting competitive advantage with the chosen unique activities. (Porter 1996)

Porter (1996) suggests three different ways of strategic positioning in order to achieve a unique set of activities. With *variety-based positioning* a company offers particular products or services with one set of activities without concentrating so much on customer segments. Bakeries and cheese and meat shops in central Europe are like this. Their offering is so attractive that customers make the effort of going, for example, first to a butcher to by meat and then to a normal super market to get the rest or the groceries. *Needs-based positioning* satisfies every need of a particular customer group, like IKEA, that is satisfying all home furnishing needs of its target customer group. Customers can also have different needs in different occasions, for example, when traveling for business or for pleasure. In needs-based positioning, it is still important to have different activities than competitors. Without this, all the competitors could satisfy the same needs and positioning would lack uniqueness and value. *Access-based positioning* is less common, it is meeting the needs of a customer group that can be reached best in a certain way. For example young people following some extreme fashion can be reached all over the world through internet whereas old people without computer skills need their services near them.

In choosing a set of activities a company decides what it does, but as mentioned earlier, another important part of strategy is the choice of what a company does *not* do.

Porter (1996) refers to this decision as trade-off. A trade-off means that more of something necessitates less of something else, like in the airline industry, you can either choose to serve meals on the flights, which adds costs and turnaround times, or you can choose not to and aim for cheaper prices and turnarounds. You cannot do both. These kinds of choices make strategic positioning more sustainable. Of course there is a possibility that a competitor tries to copy a successful set of activities. It can try to do so in two different ways: by repositioning itself to match the superior performer, or by straddling. By repositioning a company changes it whole strategy, for example, an airline can transform from being a high end airline into being a cheap one. Straddling means that a competitor tries to match the benefits of the superior performer, but still maintain its existing position. This is done with adding new services, technologies, or features to the set of activities that already exist. With successful trade-offs a company can protect the uniqueness of the activities it has chosen. By staying consistent in the choices that it makes, a company can build a brand that is hard and expensive, if even possible to copy. Consistency in the choices also makes the company's management and priorities clear. If a company tries to be everything to the customers, it causes confusion and the employees can lack a clear framework in making day-to-day decisions.

Last but not least, the activities have to fit together. When operational effectiveness is about excelling in individual activities, strategy is about combining all the activities. The activities should complement each other, for example, in a way that the costs of one activity are lowered because of the way the other activities are performed. It is a manager's responsibility to see the whole picture and to make sure that everything fits together. Nowadays, managers concentrate a lot on core competencies, key resources etc. Those are important too, but do not bring much value alone, if they do not complement the big picture. (Porter 1996)

4.1.3 Strategy execution

Strategy execution shows in the decision making through the company. Managers, line managers, and all the employees of a company make hundreds if not even thousands of decisions every day according to their own interest and according to the information they have. Neilson et al. (2008) have been researching strategy execution and have identified four building blocks that executives can use for more effective execution of their strategies: decision rights, information, motivators and structure. Decision rights meaning, that who should make what decisions is clear to everyone, information pointing at the information flow through the company, motivators like bonuses or positive feedback, and structures pointing at for example the possible career paths. Structure changes seem to be the most easy to do, they are visible and concrete. But often by making changes in the structure, only the symptoms of a problem disappear, which is temporary. The real causes of problems are often deeper, in information flows and employees' lack of knowledge about what decisions they are responsible for. Also motivators, such as salary systems depending on result, get employees to make more consistent decisions.

In young companies the information usually flows quite well, because the amount of employees is still small and everybody knows what the others are doing, the decision responsibilities are clear. But as time passes and the company grows, more people come and some go, everything gets blurry and strong management in strategy execution is needed. Information has to flow freely across organizational boarders and quickly get to the headquarters. Executives are able to coordinate the company right only when they have the most recent information about it and about the competitive environment. Free information flow also enables the transfer of best practices inside the organization. In decision making it is important that the field and line employees get the information needed to understand the bottom-line effects of their daily decision. What should be avoided is the second-guessing of decisions. When the responsibilities are given to employees and they have enough information, they should be left to work independently. This makes workers focus their energies in achieving company's mission and it is also easier to track individual achievements. (Neilson et al. 2008)

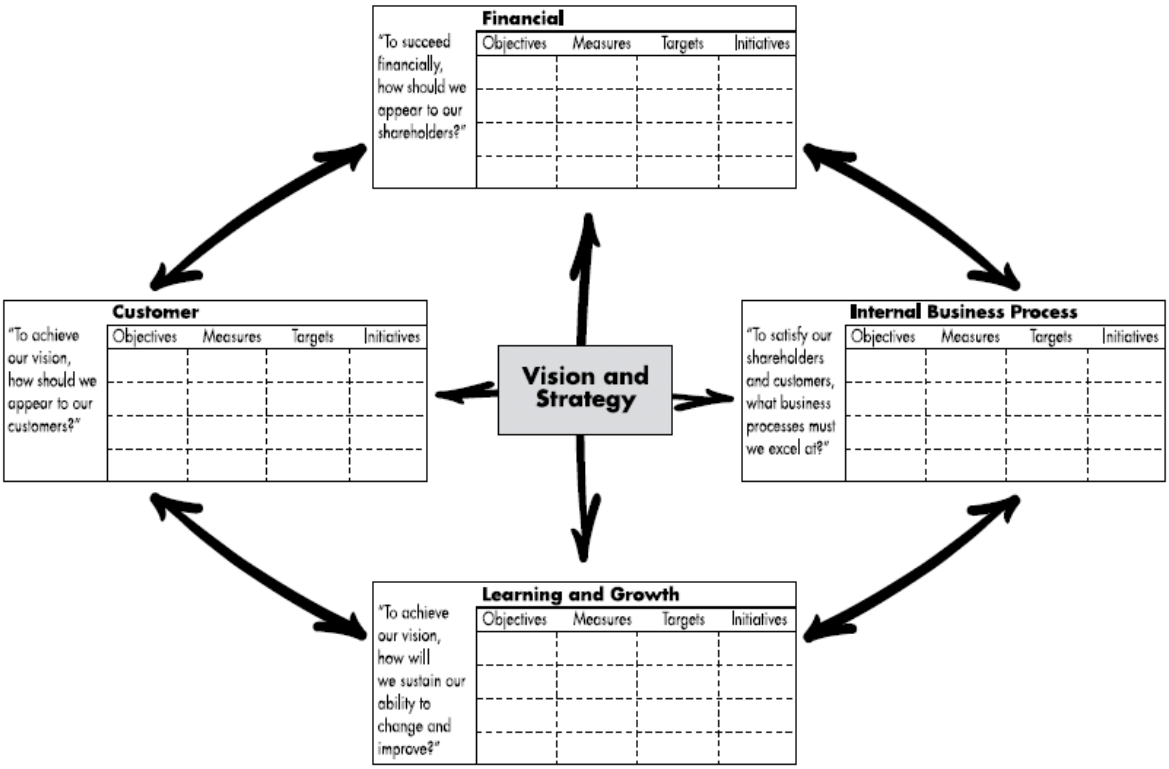
In creating a transformation program, executives should remember to take it slow. You cannot have it all at once. First steps according to Neilson et al. (2008) should address decision rights and information and after those changes are carried through, a company can focus on creating new motivators and making changes in the structure. Neilson et al. have even developed a program to help companies to understand their shortcomings and construct their improvement program. More information about that, see Neilson et al. 2008.

4.1.4 Balanced Scorecard

If a company's management and control systems are built only around financial measures, they do not relate much with achieving the long-term strategic objectives. In 1992, Robert S. Kaplan and David P. Norton introduced the balanced scorecard (BSC) that revolutionized thinking about performance metrics. Its first purpose was to tell the managers how their companies were really doing by complementing the traditional financial measures with other measures, introduced later in this chapter. In 1996, Kaplan and Norton published an article about using BSC as a strategic management tool.BSC as a management tool gives companies an advantage of linking the long-term strategy with short-term actions. (Kaplan & Norton 1996) Next the basic idea of BSC is presented and then the extended version, BSC as a strategic management tool is explained.

Balanced Scorecard translates a company's vision and strategy into implementation through four perspectives, presented in picture 4.2. *Customer perspective* focuses on how customers see the company, *internal perspective* focuses on core competencies and what the company should excel at, *innovation and learning perspective* focuses on how the company can continue to improve and create value, and finally *financial perspective* focuses on how the company looks to stakeholders. With these four perspectives BSC presents a balanced view of both financial and operational measures. Good operational measures mean good financial measures in the future. All the perspectives are presented

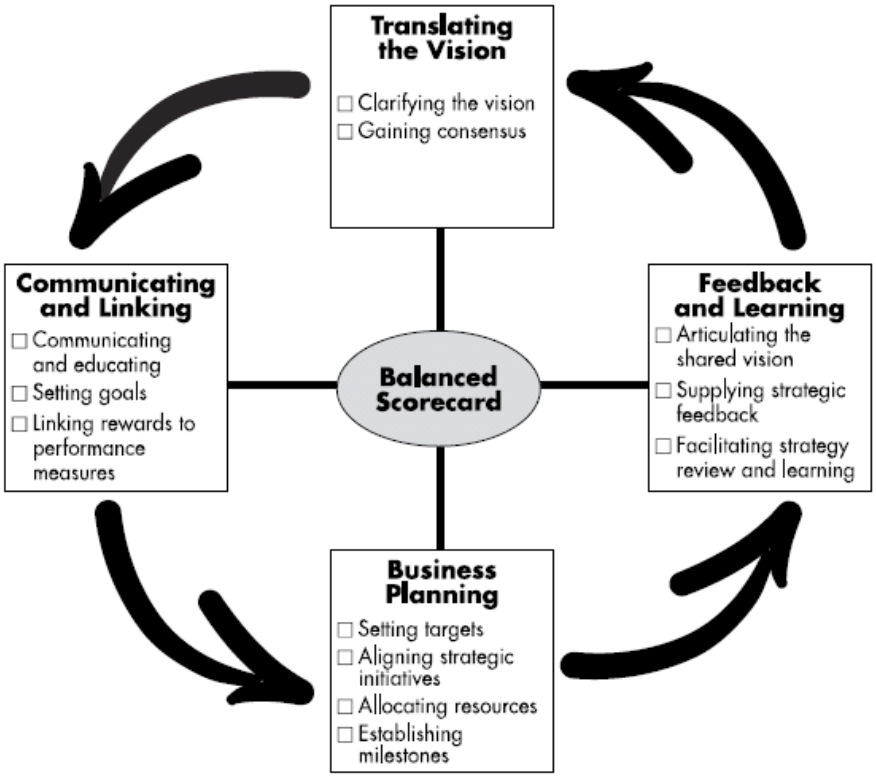
with objectives, measures, targets, and initiatives. For example an objective for customer perspective could be “responsive supply” and a measure for that “every delivery in 6 months”. First the senior managers, for example, set objectives for each perspective and then the managers set measures for those. In using BSC as a strategic management tool, after objectives and measures are set, specific short-term targets are established for the measures. This is linking the strategy to actions. Senior managers are involved, because they have the most comprehensive picture of the company. BSC gives managers an overview of the most critical measures. It is a tool to keep companies heading forward. (Kaplan & Norton 1992; 1996)



Picture 4.2 *Translating vision: four perspectives (Kaplan & Norton 1996, p. 99)*

Balanced scorecard as a strategic management tool consists of four processes that are presented in picture 4.3. *Translating vision* was explained already above so this paragraph begins with *communicating and linking*. Managers need to communicate the strategy in the whole organization and link it to departmental and individual objectives. To get the employees’ goals aligned with the strategy, managers can use communicating, educating, setting goals, and linking rewards to performance measures. This list of actions is much like the building blocks of Neilson et al. (4.1.3). Including a lot of people in creating a balanced scorecard takes more effort, but it shows in the results. Managers get a better understanding of the company’s strategic goals, and participation in the process also makes the managers to commit in achieving the goals. *Business planning* in BSC integrates strategic planning and budgeting process. This way the executives can be sure that their budget supports executing the strategy. BSC also enables

continuous *feedback and learning*. The managers have the ability to get updated information about the strategy execution, whether it is actually working, and if not, why. (Kaplan & Norton 1996)



Picture 4.3 *managing strategy: four processes (Kaplan & Norton 1996, p. 99)*

When the balanced scorecard was first introduced, many companies adopted it in order to improve their performance measurement systems. It was successful in providing clarification, consensus, and focus on the desired improvements in performance. BSC as a strategic management tool can do much more. It clarifies and updates the strategy, communicates it through the whole company, aligns unit and individual goals with it, links it to long-term goals and annual budgets, and conducts performance reviews to learn about it. BSC can focus the whole organization on executing the long-term strategy while allowing the strategy to develop and change adapting to the changes in the environment. (Kaplan & Norton 1996)

Some source literature in this chapter is quite old, like Porter's five forces (1979), but this is a conscious choice resulting from the fact that the writers still refer to his theories written long ago. However, theories this old need to be used with some criticism in mind.

The old theories of Porter are good in general, but they do not apply to all the modern industries or markets. For example, Porter (1997) claims that if the barriers of entry are low, the profits are low. The rule does not quite apply to the modern industries that

have developed after this theory was developed. Let's take the game industry as an example. The creators of Angry Birds are a group of men from Finland, who created the game on their free time for fun. Now, after just little more than a year they are all rich. The game has been downloaded millions of times to millions of smart phones and iPads. In the smart phone application world, it can be quite easy to create an application and get it to the markets. With a good idea and right timing some applications just pop up from the masses and reach great popularity. The amount of smart phone users is already large and it is growing all the time, so the potential market is huge. Internet, new technology like smart phones or iPads, and social media create new industries and possibilities, which do not always fit with the theories developed for more traditional industries. This should be recognized while using the theories. However, the tool making industry still has the same features as a couple of decades ago, so it can be reflected against Porter's theories.

4.2 Business analysis

When we are talking about business analysis, we can mean two different things: analyzing financial statement data or analyzing the whole company, its processes and the reasons for succeeding or failing in business. According to Copperhill (an international consulting company), a business analysis should cover at least the economic situation of the company, its products, production, and human resources. The economic situation can be evaluated by examining the accounts of the company. In analyzing products the next questions should be answered: Do the products have any unique selling points? What core needs are the products satisfying? Are the core competencies, technologies, and designs good enough to compete on an international level? And what is the competitive situation? In analyzing production the following should be considered: Is production efficient? Is the production based on creating real value or is it just nice to do everything self? And how the production compares to the competitors? Finally human resources are evaluated. What is the level of skills and motivation? Do the top managers have the trust of the employees? Do the human resources want, and are they willing to follow the company into new levels in business? Are the human resources organized in an interesting manner and does the company have too many or not enough employees? (Copperhill 2006)

If a business analysis is done by a consulting company, the company that has been analyzed usually gets a report of the analysis that helps managers in the decision making process. A business analysis often also brings up the negative points in a company, what is not working or what decreases the revenues. These points have to be fixed before a company can concentrate on its future plans. But it is better to notice those negative points sooner than later, because otherwise the company can hit a wall in the markets and that is often much more expensive than correcting the mistakes before they happen. (Copperhill 2006)

4.2.1 Business analysis using financial statement data

A business analysis should not be based only on financial data, but it is still an important part of it. Financial statements are the language that investors and stakeholders know how to read and want to see. Because financial statements of companies' are normally public, it is also possible to analyze competitors' performance and to try to create "inside information" about the competitors with the analysis. However, analysis like this will not be as accurate and valuable as the one made by managers about their own company, because they have inside knowledge about their own company and they can separate the information that really matters from the distortion and noise. (Krishna et al. 2008, p. 1-1)

Krishna et al. (2008, p. 1-8 – 1-10) claim that four things should be picked out from the financial statement data: *business strategy analysis*, *accounting analysis*, *financial analysis*, and *prospective analysis*. In *business strategy analysis* the key profit drivers and the business risks are recognized, and the potential profitability of the company is analyzed. This step also analyses the industry and how the companies in the industry achieve competitive advantage. Business strategy analysis should be the first step of business analysis using financial statement data, because it provides information needed in the following steps. *Accounting analysis*, step two, evaluates how well the financial statement is reflecting the reality of how the business is going. Its job is to improve the reliability of conclusions from the financial statement analysis by deleting any accounting distortions and by creating unbiased data. The third step is *financial analysis*. The goal of it is to evaluate the performance of the company now and in the past using the financial data created in step two. Ratio analysis and cash flow analysis are commonly used tools for financial analysis. The final step is *prospective analysis*, which focuses according to its name on forecasting the future of the company. In prospective analysis the financial statement forecasting and valuation is done by using the results of the three first steps as a base.

4.2.2 SWOT

As stated above, business analysis has to cover also other fields than the financial. SWOT is a simple and widely used method for doing that. With this analysis a company can find out its internal strengths and weaknesses, and evaluate the opportunities and threats of the environment. The basic idea is to maximize the advantages of the strengths and to minimize the weaknesses while also maximizing opportunities and minimizing threats in the environment. (Heizer & Render 1999, p. 45)Strengths, weaknesses, opportunities, and threats are gathered into a four field matrix. The technique most commonly used for finding these is brainstorming. (PK-RH®)

SWOT analysis can be used in all kind of companies and organizations. It can be about the whole company or just about a particular part of it. However, there should be some goal in doing SWOT analysis, because that leads to better results. With a filled SWOT matrix a company can be able to clearly see where it can improve (opportunities,

weaknesses), in what it is already good at (strengths), and as to what kind of threats it should prepare for. (PK-RH®) According to Heizer and Render (1999, p. 45) SWOT analysis is also used as a basis for determining the corporate mission and forming the strategy.

4.3 Business model

According to Mark W. Johnson (Trends e-magazine 2010, according to Johnson) a business model (BM) is supposed to answer these following three questions: (1.) Why would someone want to buy something from you? (2.) How will you make money selling it? And (3.) what, exactly, are the important things that you need to do to pull off the plan? By answering these questions a company will develop logic of how to make money, a business model. But what differentiates BM from strategy, is that BM is changing and developing all the time adapting to the changes in the environment, where as strategy gives more consistent goals for the company. Strategy tells how to change business model and companies need them both to succeed. Companies can also have several business models. For example, if a division could be spun off without any impact on the company's ability to compete and remain profitable, the BM of the division would be independent. (Cantrell & Linder 2000; 2001)

Business models can be hard to explain to outsiders, because most executives do not even know how to describe their own. This is because BMs often are just a "way of doing things" instead of explicit and written plans and executives have only practiced executing, not presenting their BMs. But if they cannot describe their BMs clearly, they cannot share them clearly in the organization either. This matters, because a small change in the BM can have a huge impact on the company's profitability. (Cantrell & Linder 2000; 2001)

4.3.1 Creating a business model

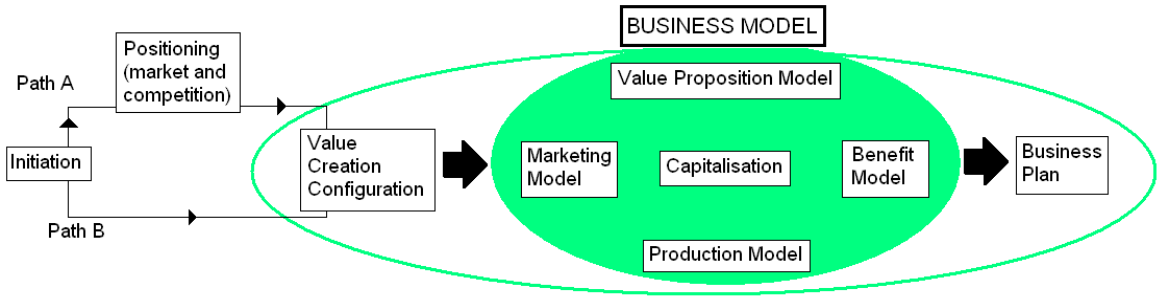
A good business model consist of the activities and approaches that make a company successful and attracting to customers, employees, and investors, and make the company deliver products and services profitably. Different companies can have totally different components in their business models, because a BM should only include the components that are part of the core logic. (Cantrell and Linder 2000) This thesis is a part of a larger research and the Lechner and Müller-Stewens (2005) business model was chosen by our research group to be used as a basis for BM theories. There other business model theories are similar, like the one from Johnson et al. (2008). They divide BM into four elements; value proposition, profit formula, key resources and key processes. Next the Lechner and Müller-Stewens theory used in this thesis is examined closer.

Lechner and Müller-Stewens (2005, p. 410) claim that business model is not just a simplified presentation of a company's strategy; BM aims for concretizing and sets the indications for achieving a business plan. The value creation has to be thought through the revenues of the capitalization perspective and it has to be concretized. For this

Lechner and Müller-Stewens give four questions to work with. The answers to these questions build an interface to operative management:

1. Which offering should be offered to which customers?
2. How and in what kind of structure should this offering be presented?
3. How do I win, nurture and keep the customers?
4. How should the earnings mechanisms be formed?

Lechner and Müller-Stewens (2005, p. 410) divide business model into four sub-models that are shown in picture 4.4. *The value proposition model* defines which offering satisfies which needs of which customers. The creation of new offerings belongs to the value proposition model. Here it is also possible to correct the positioning in the markets, if path A is chosen. If the development of the markets is still very uncertain, the process of building a BM goes through path B. How the company differentiates itself or its products from the competitors is defined in the value proposition model as well.



Picture 4.4 *Business model (adapted from Lechner & Müller-Stewens 2005, p. 410)*

Production model defines what products or services the company is offering. In this sub-model the chosen value creation configuration needs to be divided into detailed steps: the resources and skills need to be divided to the different units, the make-or-buy decisions have to be made, the tasks of the value creation partners have to be set, the communication channels between the different value creation steps, and the partners have to be chosen and installed etc. (Lechner & Müller-Stewens 2005, p. 410-411)

Marketing model defines the relationships between the customers and the company. The development of the potential of the customer has to be observed and the relevant needs of the economically interesting customers need to be recognized and responded to. But before that the marketing structure and the distribution channels, over which a company wants to win customers, have to be designed. The company has to plan how it will keep the customers, so that they will not wonder off, but end up making new purchases in the future. For example, a company can plan a regular customer program. The actions that make new offerings successful in the markets and keep them there for as long as possible also belong to the marketing model. (Lechner & Müller-Stewens 2005, p. 412)

Benefit model defines how the company earns profit. In the benefit model the price ranges are identified, the base for the revenues is fixed (units, capacity, and performance), feasible transaction revenues are being assessed, the billing and paying methods are chosen etc. The benefit mechanic does not, however, have to be the last step in the process chain. It can also be the starting point of the competitive strategic actions or even extent back to the field of positioning. (Lechner & Müller-Stewens 2005, p. 412)

All of the four sub-models are tightly dependable on each other. The capitalization perspective has to be understood as an iterative process with constant feedback and inputs from the environment that result as a need for redesigning the process. While the first three sub-models create the costs for the benefit model, the benefit model results in showing how the net revenue is created. From understanding and observing both of these perspectives, a company can monitor its total profits. (Lechner & Müller-Stewens 2005, p. 413)

4.3.2 Changing business models

Technology innovations, new laws, trends, and competitive moves can sink a company's profitability and drive it to change its business model over and over again. According to Cantrell and Linder (2000) companies succeed by choosing an effective business model, executing it superbly and mastering the ability to change it at a pace that matches the changes in the markets. Companies want to be able to change their BMs quickly and easily without deep cultural changes or organizational moves, because that kind of changes can take many years to carry out. And they are mostly not required for changing BM, because organizational units can adapt to several BMs. If cultural changes are made in business models, they should be small steps, not total turnarounds.(Cantrell & Linder 2001)

A company should, however be consistent also in which direction the continuous changes take it. Cantrell and Linder (2000) recognize four core logics of how a company will change over time to remain profitable in a changing environment. These logics are called *change models*, and consist of realization models, renewal models, extension models and journey models. Business model innovation will complete the list.

Realization models

Realization models represent the least change in change models. Using realization models companies try to maximize their profits from their current operating logic. This means that the company is not actually changing its BM, but tries to exploit the potential of it in order to grow and profit. A company can change for example by geographic expansion. Many globally successful companies have started as regional, or even local one store wonders. A company can also concentrate on brand maintenance, product line expansions, or start using additional sales or service channels.

Renewal models

Companies with renewal models change by consistently updating their product and service platforms, brands, cost structures, and technologies. They focus their core competencies in creating new positions on the price/value curve. Especially innovative companies use renewal models.

Extension models

Companies using extension models are expanding their business by adding new operations or an entire new business to existing portfolio. This can include new markets, value chain functions, and product and service lines. Extension models often involve integration, forward and backward. Some companies have even transformed their internal capabilities into new businesses.

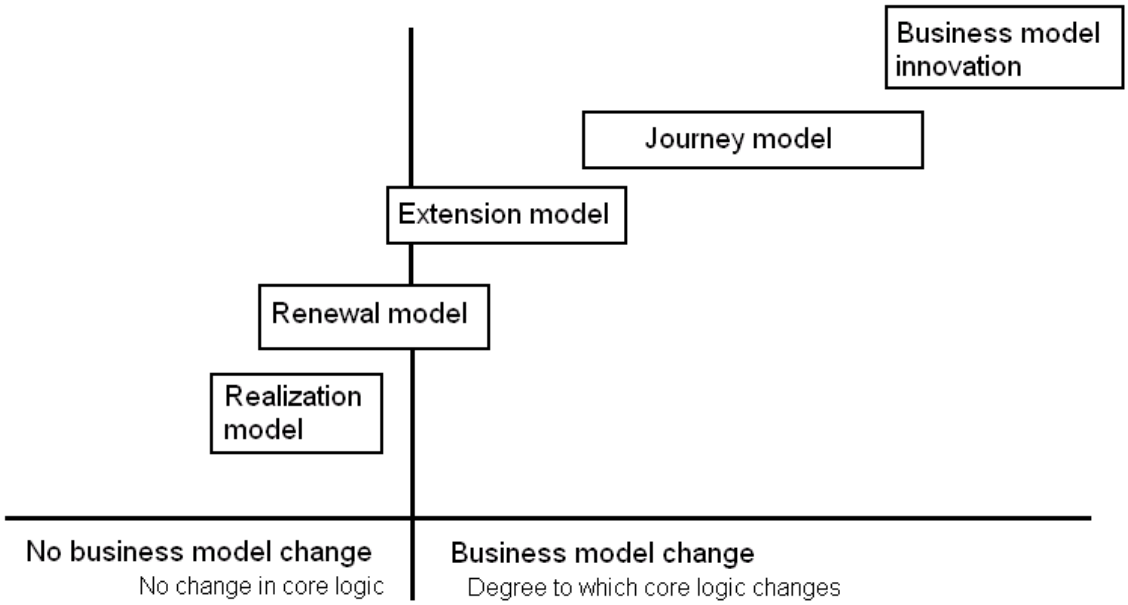
Journey models

Journey models are actually the ones changing business model the most, the other models are expanding BM to cover new markets or offerings and do not change it so radically. With journey model a company moves deliberately into a new BM and never returns. However, the degree to which the core logic changes can vary significantly. Trends e-magazine calls a major change in BM a business model innovation.

Business model innovation

Nowadays inventing a new product is not always enough. You also have to invent how and to whom you are going to sell it, this brings us to business model innovations. The basic idea is to eliminate the job a customer has to do or to solve a problem a customer wants to solve. Business model innovation is necessary, when all four sub-models (picture 4.4) need to be changed. (Trends e-magazine 2010) Picture 4.5 describes how radical of a change a business model innovation actually is compared to the change models of Cantrell and Linder (2000).

Sometimes a new product is too complicated to sell on its own and must be presented to customers in a complete package, like Apple did with the iPod music player in 2003: the iTunes Store answered the questions of how to get music and what does it cost. Second business model innovation opportunity is addressing very large groups of potential customers to whom certain markets are currently unavailable. Third, a business model can be aimed at getting the customer's job done better, faster and cheaper than competitors. The best opportunities in doing this are in situations where a certain focus of the customer's job does not exist yet. The fourth and last opportunity for business model innovation is to threaten existing high-end competition with low-end solutions in the wake of recession, when people value low prices. This move will not only steal customers from competition, but can force the competition to change their BMs. (Trends e-magazine 2010)



Picture 4.5 *Comparing change models (adapted from Cantrell and Linder 2000)*

As can be seen from the picture 4.5 the level of changing can vary in every change model up to a certain limit and the lines between the different levels are not clear. Changing business model means changing the core logic of how a company makes money. And even though Cantrell and Linder (2000) say that a company should stay consistent in the way they are changing, it does not mean that if a company does one business model innovation level change, they should do changes on that level every time.

4.4 Summary

This research report concentrates on the analyzing methods of the operations. If you are working with operations it is very important to understand the meaning of the strategy in the background. Strategy is a long term plan about what a company does and what it does not do. Porter's five forces (1979) help a company to understand their own industry and that way shape their strategy. With strategic positioning a company tries to find a unique set of activities to create a lasting competitive advantage. Strategy is executed through decision making and balanced scorecard (Kaplan & Norton 1992; 1996) can be used in implementing strategy and as a strategic management tool.

Lechner and Müller-Stewens (2005) divide business model into four elements; value proposition, profit formula, key resources, and key processes. Business model has to be able to change constantly and when all the four elements change, it is called a business model innovation.

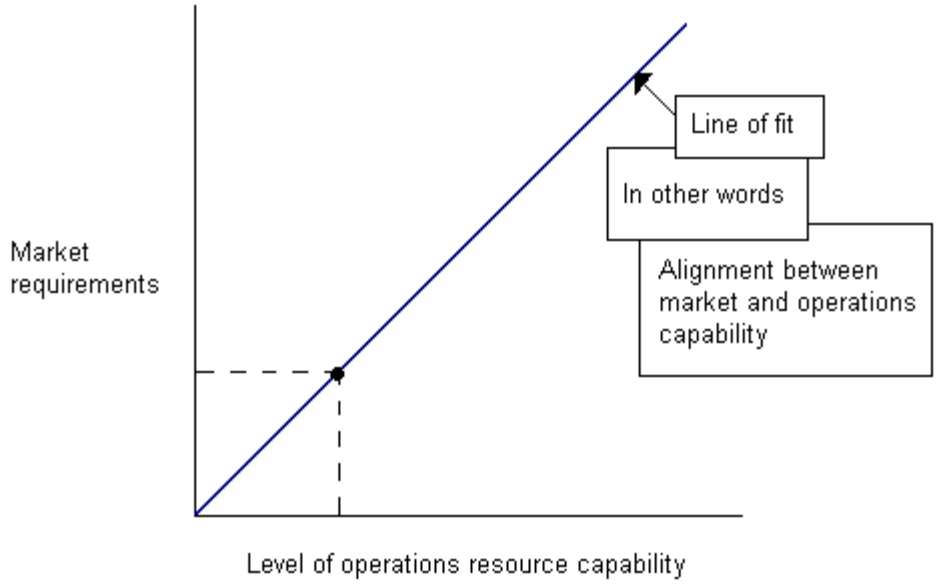
5 INTO OPERATIONS

This chapter will concentrate in more detail in what operations are, how to put them into action, and how to evaluate them. The questions about how to come up with strategy or business model have been answered in the previous chapters, but how do we actually get the people inside the company to do the things described in them and what kind of challenges and problems might we face? The suitable answers for tool makers to these questions have been picked out of literature into this chapter. First the chapter concentrates on clarifying what is an operations strategy and what general things should be considered in implementing it. Methods, tools and techniques for analyzing, managing, developing and implementing certain operations tasks are presented in chapter 5.3.

5.1 Tool maker's operations strategy

Operations can have different goals, like productivity, quality, dependability, or consistency. Operations also have a strategy that guides them towards the chosen goal or goals. *Demand-flow manufacturing* is a typical operations strategy for a tool maker. Mostly it is carried out with a job shop layout (3.3). It means that every action is based on the demand of other units, and ultimately the demand of customers. But a company can also combine more strategies and get speed in their decision making as a result. *Emphasis on quality* is an operations strategy where products are designed and produced right the first time. It requires considering what things are actually possible to produce with good quality and competitive prices, listening to customers, and being creative. Every employee in the company must be involved in creating quality with their own responsibilities and resources. *Flexible Manufacturing System* (FMS) as an operations strategy allows the system to react in case of changes which for tool makers are common. It builds mini-assembly lines or cells for the parts and processes that are repetitive. Companies that do not have FMS can respond as quick to customers as companies with FMS only with keeping finished goods inventories, which is expensive. *Automation* is a decision between speed and expensive equipment or less of both. If a company decides to steer its operations strategy towards automation, they also have to rethink their designs and processes. Parts have to be designed so that they facilitate quick, have inexpensive setups, and greater interchangeability. The other challenge is to replace and train the employees from handcraft workers to automation controllers, and motivate them for the new job. With operations strategy called *decentralized operations*, decision making is spread away from the top managers, or in production, spread to many locations. This leads to more flexibility, speed, and quality in decision making compared to centralized operations. (Summers 1998, p. 12-14)

Slack and Lewis (2011, p. 280) talk about operations strategy process, in which four elements can be recognized: formulation, implementation, monitoring, and control. They say step-by-step models are not reality, because in reality the operations strategy process is much messier. Implementing should always ensure that operations strategy is achieved, but the ways of implementing are individual for every strategy, so there are no readymade directions of how to implement your exact operations strategy. Organizational and environmental changes and the changes in the operations strategy implementation need to be understood. This can be hard, especially for the employees that have not been included in the strategy formulation process. The changes are made so the operations resources capability could meet the changing requirements of the markets. This connection can be described with a diagram (picture 5.1), where market requirements are on the vertical axis and operations resource capability on the horizontal axis. Why, how, and how much are things going to change? The answers can be seen in this diagram. It also shows the balance between the two axes. Problems can appear if this balance is not maintained: if a company does not meet the market requirements or if it has some extra resources that can not satisfy any requirements. These risks need to be included in the implementing plan.



Picture 5.1 *Fit between market and operations capability (adapted from Slack & Lewis 2011, p. 282)*

Walters (2002, p. 4) identifies *strategic operations* as an approach, where all the activities and all the organizations in the value chain are recognized. Companies that are customer focused can build value chains that extend all the way from suppliers to customers. With strategic operations a company tries to evaluate where and by whom in the value chain should every action be performed to gain the best competitive advantage. For using this kind of approach, good relationships with the suppliers are essential. Walters sees five key features for an operations strategy: first a visionary is needed to create

a more effective business model by seeing how the pieces should be put together. Second, the processes that need to be considered are the inter-organizational rather than the intra-organizational. Third, a supportive infrastructure that facilitates integration is needed. Fourth, the customer needs to be thought of as an integral part of the chain, as a major stake holder. And fifth, a company needs an inter-organizational performance planning system.

Boer et al. (2007) divide operations into five key dimensions of an operations strategy process: technical-rational, cultural, political, project management, and facilitation. *Technical-rational dimension* refers to developing and implementing change in decision categories like capacity, supply chain, process technology, and development, and organization (Boer et al. according to Slack & Lewis 2002). *Cultural dimension* refers to changes in the knowledge, competencies, perceptions, communication patterns, logics, values, needs, and interests of the workforce (Boer et al. according to Misterek et al. 1992). *Political dimension* tells about the alliances that workers form and the power resources that they possess (Boer et al. according to Menda and Dilts 1997; Badham and Buchanan 1999). Project management and facilitation refer simply to managing all projects and managing the facilities for all the actions like workshops or training.

As every strategy, every operations strategy is individual as well. Operations strategies can be built up and thought through more than just one of these theories. But people are, in some level, the same everywhere. That is why some possible problems have to be acknowledged in implementing every operations strategy. These problems and how to deal with them are discussed in the next chapter.

5.2 Problems in implementing operations strategy

According to Boer et al. (2007), cultural and political factors can stand in the way of change, when employees are not willing to make the required changes. “This is the way we do it, because this is the way it has always been done” is a typical attitude. The problem can be solved by educating workers about why the changes are made or by firing the workers who are unwilling to change and hiring new ones with more skills and knowledge. This seems a bit rough, but luckily a worker often gets motivated to make changes just by understanding that the changes are profitable for the company. Chaos and complexity in the process can also be caused by an actor expressing his opinion too late in the process. In some cases this can result to beginning the design process again from scratch, for example, when a top manager suddenly decides that a new process is not fast enough, or that producing a new product is too expensive. Some new factors can slow down a process as well, if they come to the picture in the middle of it, like changing CEO, and having a new one with new opinions. And of course the changing environment, that has been discussed earlier, affects the implementation. It can cause new problems that need to be solved during the process.

Even without the problems that Boer et al. recognized above, operations management is a hard job. It requires understanding many elements and having a huge amount

of knowledge from the markets and from the operations elements. Operations managers do not only need knowledge, experience, and decision making abilities, but also visions and willingness to experiment. They need to analyze the mistakes made in the past and come up with creative new solutions for solving problems. An open discussion forum is an important element assessing all the relevant information. Why operations strategy implementation is more difficult than formulating operations strategy, is that in implementing the elements need to be picked out from conversations and turned into actual changes in the operating process. (Tan & Matthews 2009, p. 82-85)

Who is responsible for implementing operations strategy? Ask Slack and Lewis (2011, p. 299). This can be unclear in a company and result confusion. Slack and Lewis (2011, p. 299-300) answer this question with a couple of options. In big organizations there can be a special department, whose duty is to create the ways operations should be managed. Smaller companies, like the most tool makers are, however, do not have that kind of resources and the responsibility is divided between the line managers and staff. Staff here means the people who build up company's operations capability, and monitor, plan and shape it. Line managers manage the daily operations and solve unexpected problems. Staff keeps an eye on developing different operations and looks forward to the markets and line managers concern about meeting customers' current expectations. There is also a central operations function, which affects operations from the headquarters of an organization. It provides operations function technical advice, information system capabilities, laboratory testing services, improvements teams, quality procedures, etc. Central operations can have four different kinds of roles depending on if they have a top-down or a bottom-up view of the world and if they are more focused on market requirements or operations resources. These roles are governor, curator, facilitator, and trainer. (Slack & Lewis 2011, p. 301, according to Merali & McGee 1998) *The governor* role is about controlling the performance of operations, setting priorities, measuring performance, and comparing it to the targets. *The curator* role is softer; in it the central operations collect performance data and inform operations on it. *The facilitator*-role in central operations gives advice and support to operations, and encourages learning to enable deployment and developing of the operations capabilities. *The trainer* role is about instructing the operations in developing and deployment with improvement methods. Central operations can have more roles than one, but usually one of the roles is clearly the strongest. Small tool making companies do not necessarily have head quarters and the duties described above lie on the shoulders of the CEO.

5.3 Theories and techniques for managing, analyzing and developing operations for tool makers

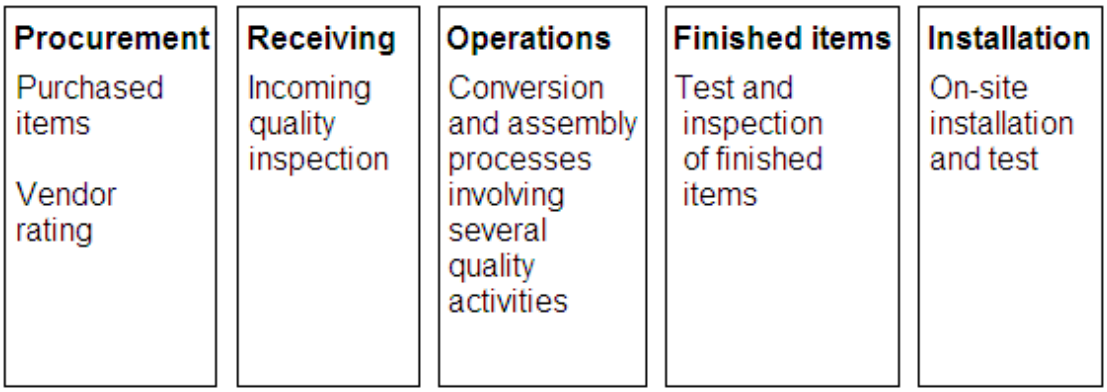
Operations or operation management means a business model put into actions. Heizer & Render (1999) define ten decisions of operations management that need to be considered in planning, managing, evaluating, and developing operations. These are managing quality, design of goods and services, process strategy, location strategies, layout

strategies, human resources, supply-chain management, inventory management, scheduling, and maintenance. In addition to these ten decisions, Hill (2000) highlights time and productivity, improving operations and capacity management. Gino and Pisano (2008) on the other hand divide operations management into three different goals in their article about behavioral operations: design, management, and improving. Designing includes specification of processes, policies and strategies. For example, setting inventory policies or determining location and plant size. Management includes decisions and actions within the margins set by the designs, for example implementing policies, procedures and strategies. Improving means experimentation and learning activities towards increased operations performance over time.

Next some of the Heizer's and Render's (1999) ten operation decisions and Hill's (2000) operations tasks will be further examined. The chapters are supplemented with facts, tools, techniques, and point of views from other literature as well. Some operation tasks of Heizer, Render and Hill are left out, because not all of them have a big impact on tool makers, like location strategies. Logistic costs of a product in the tool making industry are relatively small compared to the price of a product and customers often have to order their tools from far away anyway. We start with managing quality, an operation task that in some way affects all other operation decisions.

5.3.1 Managing quality

Quality for tool makers is an important issue, because the tool makers produce expensive and complicated systems that are supposed to last for years or even decades. But how does quality show in operations and how should it be managed? From an operations perspective quality means meeting customers' expectations constantly. For recognizing that every product does this, a specification needs to be defined so that the dimensions involved can be measured and controlled. *Variables*, such as length or weight of a part can be measured on numerical scales. *Attributes* can be judged or checked by using the qualitative conditions of a process without exact measurements. Next in line are the decisions about which dimensions will be checked, where and how. An example about where the checks are made is shown in picture 5.2. For example the incoming materials or parts can be checked before storing them or the ready products can be tested on site during the installation process for the last time. Picture 5.2 shows that there are many places in the whole process where quality checks can be made and that some materials and parts go through many different checks at different points of the process.



Picture 5.2 *Where quality checks can be made in a process of a manufacturing company (adapted from Hill 2000, p. 309)*

For improving quality, the causes of below-standards-quality should be identified for knowing where to improve. Quality has to be built into work, so that the work is done right the first time and every time. Managers should manage quality by preventing the mistakes and aim for error-free work. In the case that mistakes happen there should be no blaming fingers pointed, instead the question "why" should be asked. (Hill 2000, p. 304-310) Quality improvements help companies to increase market share and reduce cost. Higher quality can turn out to be more rapid response, lower prices, and higher reputation or cost decrease by less rework and less warranty costs. (Heizer & Render 1999, p. 78) Productivity and quality are not trade-offs. If anything, improved productivity should be recognized as a by-product of improved quality. (Hill 2000, p. 315 according to Deming 1982)

Quality philosophies

The next three paragraphs will present three different quality philosophies from W. Edwards Deming, Joseph M. Juran, and Philip B in which the thoughts from the previous two paragraphs are developed further. Crosby. Deming, Juran and Crosby all claimed that the key to quality is good management and gave advices, on how to achieve it. The different perspectives are gathered here. After that quality management trends are shortly presented and finally tools and techniques for managers to use in quality management are gathered together.

Deming (Hill 2000, p. 313 according to Deming 1986) guides operations managers to accept the need for continuous change and innovation in his 14 points program. He also claims that communicating operation strategies through posters and slogans on the walls is superficial and does not help anyone to do a better job. Instead, managers should make sure that employees have the tools and training for doing their tasks and improving processes. Everyone in the company should be encouraged to educate themselves and to make self-improvement. Managers should be leaders, not supervisors. They should encourage employees to ask questions, report problems, express ideas, and come up with solutions. They should also focus on quality instead of quantity. Barriers

between staff areas need to be broken down. It is essential that different departments know about problems in the other departments and can help find solutions. For example, if it is problematic to work with a special material, design, research, and sales people can try to find a better one. Like this all the departments are working together towards the goals of the company. Employees should be allowed to be proud of their work and managers should always show example with every action they do, because quality begins with managers. Deming pointed out that 85 percent of quality problems could be traced to management actions and failures. He warned companies about not being consistent; companies need to commit to the quality improvement without allowing any changes. He told companies to avoid pursuing short-term profits, because it can sacrifice long-term growth. Companies should concentrate on making sure that their managers help people with leadership instead of concentrating on annual performance evaluations that provoke rivalry among managers and temptation to concentrate on short-term performance before the evaluation. Too much mobility of managers should be avoided, because it is better to have managers that can fully understand their department and work there so long that even they can see the long-term changes through. And finally when assessing performance, it is important to also consider other figures than just the ones related to money.

Juran (Hill 2000, p. 316, according to Juran 1979; 1981) introduced a concept, cost of quality (COQ), which clarifies to top managers the meaning of quality and the savings that quality programs bring to the company, all in numbers. It can be used also in setting goals for quality. COQ divides quality costs into five categories. The first is *internal failure costs*, which cover all the resources used to fix quality failures that are detected before shipping products to customers. The second is *External failure costs*, which sums up from finding failures after the products have been shipped to customers. This includes returns, warranty claims, handling complaints, and repairs. The third, *appraisal costs*, associates with quality checks. These can be costs from incoming inspections, purchase and maintenance of test equipment, quality staff or product, service, process, and delivery system checks. The fourth is *prevention costs*, which results from activities that are trying to prevent quality failures. These activities include quality planning, new product reviews, process control, data collection and analysis, reporting, and improvement activities. The first step in using these categories would be to reduce the costs from the first two categories. But when that is done it is important to find a balance where the total quality costs stay as low as possible. This requires also that there are not too many quality checks and testing stations. The managers have to get the whole company committed to quality and continuous improvement. In doing this, Juran agreed with Deming that posters on the walls do not bring results and that the key to change and commitment is in management.

Crosby (Hill 2000, p. 320, according to Crosby 1979) also thought that the key to quality improvement was in managing, high managing standards and communicating. Like Hill, Crosby thought that quality means meeting customer’s expectations and like Juran, he also highlighted preventing failures. Crosby claimed that zero defects should

be the managing standard and like Juran, he found it important that quality costs can be expressed to top management in clear numbers. Crosby also made a 14 step program for quality management including a lot of the advice mentioned above. The last step of the program was to do all the steps again. This reflects the fact that once you start a quality process, it will never stop.

Quality management trends

Quality philosophies give guidance that managers can use in every kind of managing assignments. Quality management trends are more detailed ways to manage quality and although it would be possible to mix some of them, usually a company chooses just one. *Total quality management* (TQM) is one of the first management fashions invented (Slack & Lewis2011). It encompasses the entire organization from suppliers to customers, which is important because quality issues effect every other operation decision or task some way. All the quality philosophies above are actually implementing TQM. Heizer & Render (1999, p. 82) developed Deming's (Hill 2000, p. 313 according to Deming 1986) 14 points further into five concepts in order to implement TQM; continuous improvement, employee empowerment, benchmarking, just-in-time (JIT), and knowledge of TQM tools. The basis of continuous improvement is that every aspect of every operation can and should be continuously improved. Employee empowerment means that employees should be involved in every step of the production process. The ones working in the production processes understand the problems of them best and have that for a lot to give for example to the design processes. The employee empowerment can be done by building communication networks that include the employees, by training supervisors and managers to be open and supportive, by giving more responsibility to the production workers, by building high morale into the organization, and by creating organizational structures like teams and quality circles, which are discussed later in chapter 5.3.3.Benchmarking is explained in detail in chapter 5.3.8, improving operations. Just-in-time (JIT) means delivering products just when they are needed. By implementing JIT a company can reduce its inventories and improve its quality. Knowledge of TQM tools means that for implementing TQM everyone in the organization must have the training needed to understand and to use the tools of TQM.

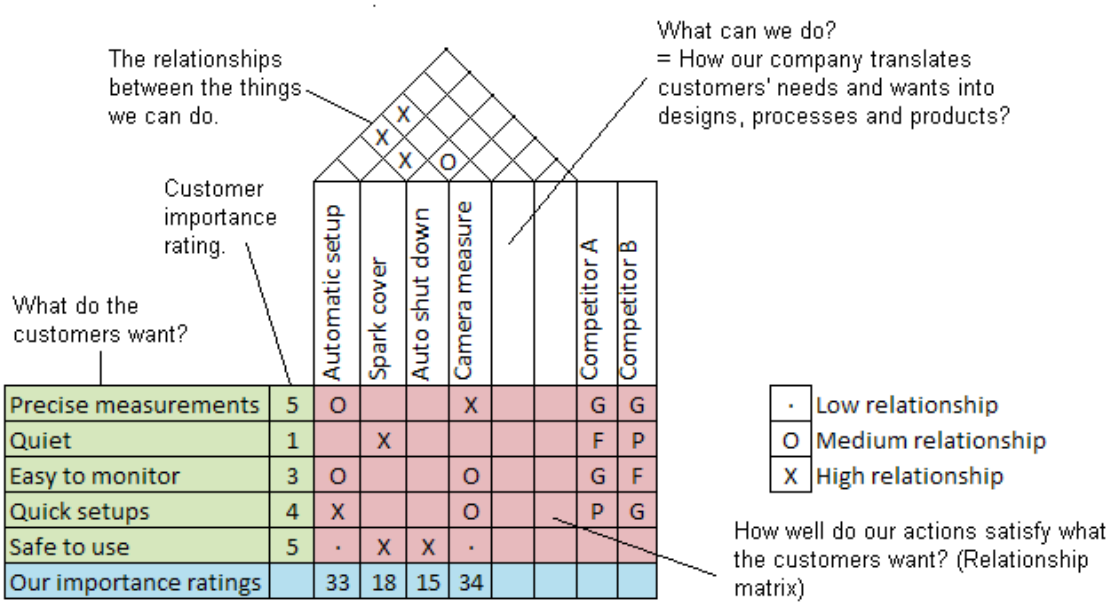
One well known approach to quality management is *lean*. The four elements of lean are waste elimination, behavior, synchronization, and customer focus. In other words the goal of lean is to deliver exactly what customers want, in exact quantities, exactly when needed, exactly where required and at the lowest possible cost. Compared to TQM and lean, *business process reengineering* is advocating more radical changes rather that incremental changes to processes. Its elements are rethinking business process, striving for dramatic improvements, having those who use the output from a process performing the process, and putting decision points where the work is performed. The ultimate goal of *Six Sigma* is to remove all the defects. It is a statistical approach that claims that the defects in a process have to be counted before it is possible to improve it systematically. (Slack & Lewis 2011, p. 89-105)

These quality management trends are not strategies, but choosing one is a strategic decision. Using them requires professionals that fully understand them. It is a big process to start implementing one of these trends and if a company does it, it should fully commit to it. (Slack & Lewis 2011, p. 107-110)

Tools and techniques for (total) quality management

To support the chosen quality management trend or just to support quality management in general, there is a wide range of tools. The use of the tools is going to help managers to identify problems, facilitate improvements, implement solutions, and sustain new ways of working. (Hill 2000, p. 350) A set of quality tools is presented next.

Quality function deployment (QFD) should be used in the early stages of the production process to determine what will satisfy customers' needs and to translate that into the target design. A tool to do this is called the ***house of quality***, which defines the relationship between the customer desires and the product. An example of a house of quality analysis for cutting tools manufacturer is presented in picture 5.3.



Picture 5.3 *House of quality, cutting tool producer (adapted from Heizer & Render 1999, p. 88)*

For building a house of quality six steps need to be performed:

1. Identifying what customers want. These wants are placed in the down left corner of the house of quality. In this example (picture 5.3) they are precise measurements, quiet, easy to monitor, quick setups, and safe to use.
2. Identifying how the products will satisfy what the customers want in other words identifying the hows. The hows are placed up in the middle and in this example they are automatic setup, spark cover, auto shutdown, and camera measure.

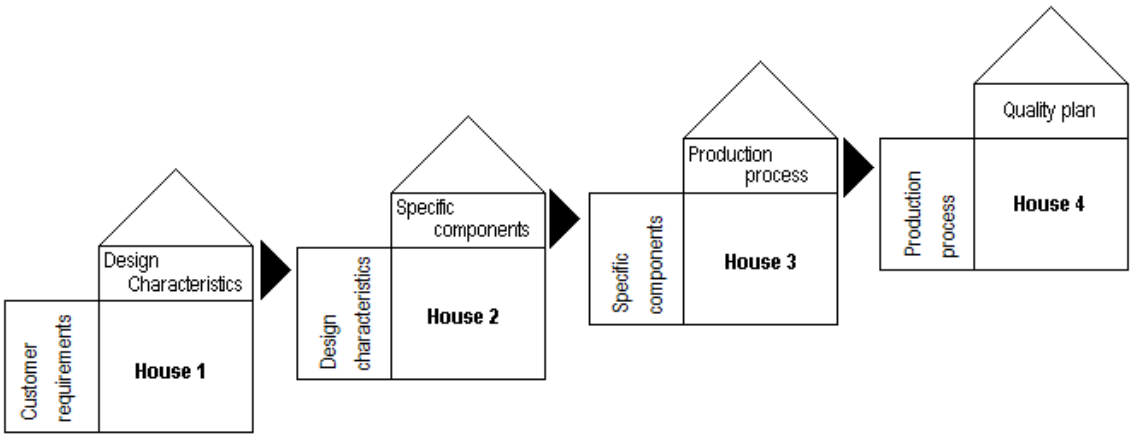
3. Relating the customer wants to product hows by building a matrix that will show this relationship. The relationship can be high, medium or low and the symbol matrix is placed to the middle.
4. Identifying how the internal hows are related to each other. The same symbols from step 3 are also used for this relationship matrix and in the house of quality it forms the roof, so the matrix is placed up in a form of a triangle.
5. Developing importance ratings for customer and the company, and entering them to the matrix. Customer importance ratings are formed according to the wishes of customers and placed between the customer wants and the relationship matrix. Company importance ratings are counted and placed on the bottom row. For example the importance rating of automatic setup is

   $$2*5+2*3+3*4+1*5=33,$$

   where the first number of a multiplication is always the relationship (high = 3, medium = 2, low = 1) and the second number is the customer rating (5 is the highest).
6. Evaluation of competing products, how well do they meet the customer wants? The evaluation scale is good (G), fair (F), or poor (P). Results are placed to the right side of the relationship matrix.

(Heizer& Render 1999, p. 86-89, according to Akao 1990)

Another use for QFD includes more houses. It is a house of quality sequence that indicates how to deploy resources to meet the customer wants. House 1, design characteristics, in picture 5.4becomes the input for house 2.The design characteristics are satisfied in house 2 with specific components. Specific components in house 2 then become the input for house 3 and so on. The process will go on as picture 5.4 shows and the end result is a quality plan that will ensure the quality in the houses 1-3. "The quality plan is a set of specific tolerances, procedures, methods, and sampling techniques that will ensure that the production process meets the customer requirements." (Heizer & Render 1999, p. 86-89, according to Akao 1990)



Picture 5.4 *House of quality sequence (adapted from Heizer & Render 1999, p. 89)*

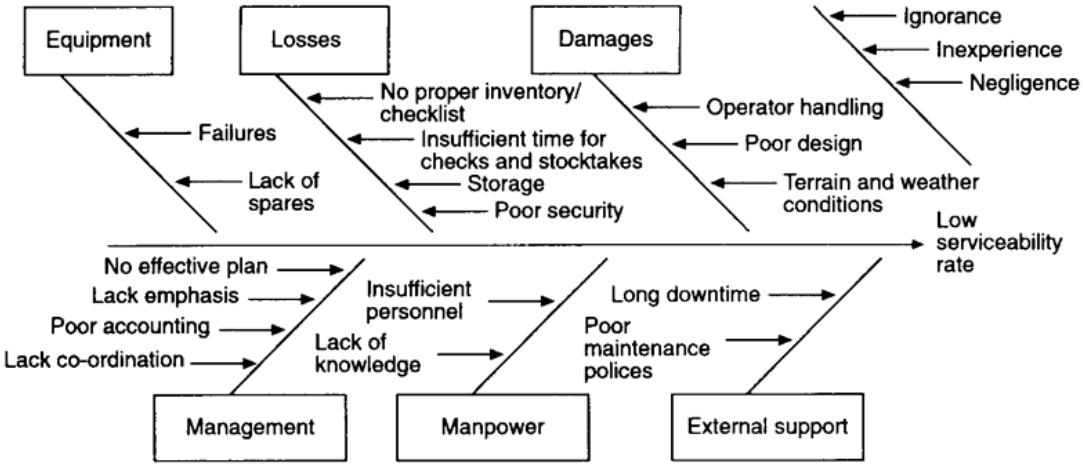
Taguchi technique is also aimed at solving the quality related problems at the product and process design stages. The first of the three concepts in the method is quality robustness which means products that can be produced consistently in adverse manufacturing and environmental conditions. The idea is to remove the effects of the causes, not the causes themselves. For example, in a painting room workers constantly breathe poisons in, but it is cheaper and easier to give them masks than remove the paint mist from the air. The second concept is the quality loss function that identifies all costs that are connected to poor quality. The list of costs is the same as described earlier in the cost of quality (COQ) concept. However, Taguchi's method shows how quality costs increase when product quality moves away from what a customer wants with a mathematical function.

$$L=D^2 C$$

In this function L = loss, D^2 = square of the deviation from the target value and C = cost of avoiding the deviation. The final concept is target-oriented quality, which is a philosophy of continuous improvement for bringing the product exactly on to the target value. (Heizer & Render 1999, p. 89, according to Ealey 1988; Peace 1993)

Pareto charts or ***Pareto principle*** organizes errors, problems and defects and helps to focus on problem solving (Heizer & Render 1999, p. 90). Pareto principal indicates that 80 percent of the problems are caused by 20 percent of the causes. The chart is build with data about what kind of errors have been made. It can be used to evaluate which cause would bring most savings, when solved. (Hill 2000, p. 326) Pareto principle is also used in ABC analysis in inventory management (5.3.7).

Cause-and-effect diagrams, also called fishbone or Ishikawa diagrams, identify the possible causes for quality problems and locations for inspection points. Heizer and Render (1999, p. 92) claim that operation managers should start the diagram with four categories; material, machinery/equipment, manpower, and methods. But probably there are as many variations of the fishbone as there are people doing it. Anyway, it is an analysis tool where the analysis of the symptoms and causes yields the problem statement (Hill 2000, p. 327). An example of the method explains it best and is shown in picture 5.5.



Picture 5.5 *Example of a cause-and-effect diagram. (Goh and Tay, 1995)*

The big branches are drawn first. In picture 5.5 these would be equipment, losses, damages, management, manpower, and external support. Then every branch is handled by writing what reasons cause the big branches on smaller branches. The reasons for equipment problems in picture 5.5 are failures, and lack of spares. This leads to detailed reasons about why the bigger problems occur and can show some causes that are really easy to eliminate or correct.

A check list is probably the simplest tool for collecting data about quality and other problems. For example in a work center or a job shop the workers can just mark the cause of a problem to a list at the moment when it occurs like in table 5.1. In the finished list the total amount of problems are shown in numbers and percent.(Hill 2000, p. 327) The collected data is used for analyzing where to improve and what.

Table 5.1 *Example of a check list in one job shop (adapted from Hill 2000, p. 327)*

Problem	Frequency	Total	Percent total
No parts in stock	xxxxx xxx	8	29,62962963
Defect in part	Xx	2	7,407407407
Machine out of order	Xxxxx	5	18,51851852
Grinding error	xxxxx x	6	22,22222222
Drilling error	Xxxxx	5	18,51851852
No tools available	X	1	3,703703704
	Total	27	100

After collecting data, the next step is to recognize why defects happen. One tool for this is a ***scatter diagram***. It shows the relation between two variables such as the amount of mistakes per month and how long an employee has been working for the company or how much he/she has been trained. If the points of a scatter diagram are on the same line, it shows that in fact inadequate training is causing the problems in the beginning of one's carrier. (Hill 2000, p. 329)

Checking 100 percent of the products, or parts is not always possible and rarely needed. ***Sampling*** means checking just random pieces and counting with statistic the probability that the rest are good too. (Hill 2000, p. 329) Tool makers might use sampling to check some incoming materials or big amounts of small parts like screws or bolts. Since the amount of ready products in tool making industry is quite low and the products are expensive, it is of course, worth it to test them all.

In the tool making industry, quality checks differ from checks made in mass production. Quality limits and standards have to be specified individually for every product and every single product should be tested before delivery and after installing it in the customer's location. In case of quality problems, it is expensive to have massive tools sent back to the production plant and it can take a lot of time too. Also repairing the problems at the customer's location can lead to large costs, because of inclusive costs, for example caused by interrupted production, can get very high. If suppliers are trusted partners, the quality checks of the parts or materials that the suppliers provide can be performed already at their facilities by the suppliers' employees. Also subcontractors can be included in the quality process by giving them the responsibility of quality checks.

5.3.2 Analyzing and developing products and processes

Products and services are what the company is ultimately judged on; they are what everybody on the outside is seeing. There is a connection between how a company develops its products and how well they succeed on the markets. These aspects make products and product development a key issue for operations management. (Slack & Lewis 2011, p. 246) Strategic decisions of what to do and what not to do (4.1.1) define the big picture of what products the company is producing, the details come from design, operations, processes, and product development. There are numerous new product opportunities all the time and several factors affecting them. Economic, sociological, demographic, technological, political, and other changes need to be acknowledged. (Heizer & Render 1999, p. 194-196) But for tool makers this is not so simple, because they often feel the effects of the changes through some other company. For example, a sociological change like decreasing family sizes affects an automobile manufacturer with a changing size of preferred automobile, but it depends on the automobile manufacturer how it will affect the tool maker.

"Even small advantages in product and service specifications can have significant impact on competitiveness." (Slack & Lewis 2011, p. 247) That is why it is important to constantly seek those small advantages by product and process development. Here processes and products go hand in hand, because product development often needs or comes from process, or technology development or innovation. And the other way around: after designing a new product, a new process of how to produce it has to be designed (Hill 2000, p. 58).In product development it is important to check the markets on whether customers will actually buy the new technique or product. Testing markets

with prototypes will reduce the risk of investing large amounts in wrong products. (Hill 2000, p. 64) The customers of tool makers know exactly what they want and force the tool makers to develop new solutions constantly (Slack & Lewis 2011, p. 246-248).An effective way for getting new ideas is to create a platform, where employees can express theirs, like continuous improvement in chapter 5.3.3. (Hill 2000, p. 59)

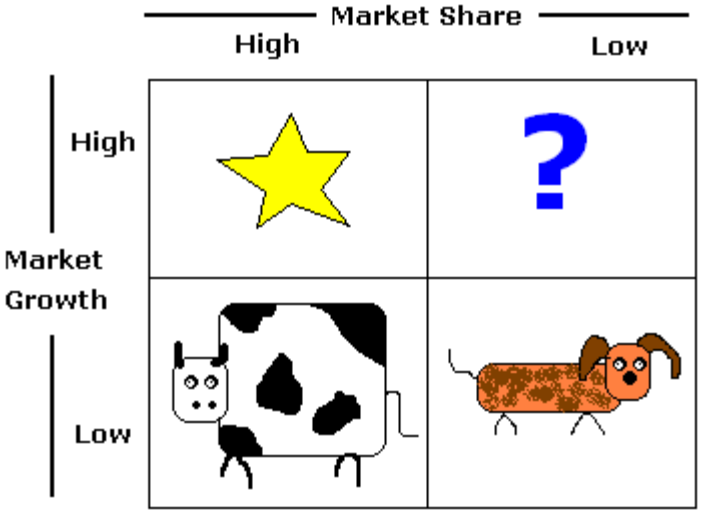
Modularity is a strategy in which some parts of the product are standard modules and where modules and possible customized parts create a whole product. Customers can be offered a set of modules from which to choose from and their additional individual needs can be filled with customization. For tool makers, making certain type of machines, for example steel cutting machines can be a way to save storage space and reduce lead times. Modularity also provides other advantages. Because the modules are standardized, they can be produced with low cost and innovations can be tried out on one module instead of the whole product. One step towards mass production from modularity is mass customization. It is a strategy where a company mass produces a set of products that can still be customized for individual customer needs. (Slack & Lewis 2011, p. 252-253)

Even a good process or product does not stay superior forever and new ones have to be created. But a company cannot produce unlimited amount of products, it has to be able to evaluate which are the ones at the end of their routes. A company also needs a tool for analyzing where the points that need improving are in a process. Luckily, there are tools for analyzing and developing products and processes. The portfolio technique (Tutor2u) concentrates on all the products of a company. It can be helpful in finding new product opportunities and in deciding which products a company should give up on. With value analysis, (Hill 2000) costs of a product can be minimized without losing its value and value stream mapping (Osterling 2009) concentrates on one product or process and aims for deleting the activities that do not create value. Flow diagrams, process charts, and time-function mapping are tools that Heizer and Render (1999) give for analyzing and developing processes. Often products are also evaluated with a life cycle curve. It claims that every product goes through five stages; introduction, growth, maturity, saturation, and decline. (Hill 2000, p. 65-67) For tool makers this technique can be helpful when it comes to tools that are ordered more often, or they can use the curve to evaluate how much longer certain products will be popular and are more tools needed to produce it. But for specified tool orders, the ones that will most likely be ordered only once, a life cycle analysis is unnecessary.

Portfolio technique

In the portfolio technique strategic business units (SBUs) that build up a company, are divided to a four field portfolio. SBUs can be different products or even different brands, depending on what kind of company is making the analysis. A portfolio, according to Boston Consulting Group, is presented in picture 5.6. Market share on the horizontal axis tells about SBU's strength in the market and market growth on the vertical axis tells about how attractive a certain market is at the moment. (Tutor2u)

Stars have a strong position in markets that have strong growth. These products or businesses often need heavy investment to continue growing. Eventually, the growth will slow down and stars will become cash cows. *Question marks* also have potential markets, but it is not yet sure that the products have enough strength to become stars. This transformation often needs heavy investment as well, so the managers have to think hard on which question mark to invest in and which ones they should let fade. *Cash cows* are in the other corner of the portfolio; these are already successful SBUs with high market shares in markets that do not grow much anymore. Cash cows do not often need much investment, but they need to be managed well for continuous profit that is needed for investing in the stars and question marks. *Dogs* refer to SBUs in low-growth markets with relatively low market shares. These SBUs are rarely worth investing in. (Tutor2u)



Picture 5.6 *The Boston Consulting Group Box (Adapted from Tutor2u)*

With portfolio analysis, a company should develop new products and businesses to add to the portfolio and think about which SBUs could be removed from it. There are four possible strategies for each SBU: The company can invest to increase market share (Build share). The company can invest just enough to keep SBU's current position (Hold). The company can reduce the investment to maximize short term profits of the SBU, though this can lead to a star becoming a cash cow (Harvest). Or the company can sell or divest a SBU and direct the resuorces e.g. to a question mark (Divest). (Tutor2u)

Value analysis

By value analysis, a company tries to reduce costs by considering the functions that a product or a service is supposed to perform. It aims at developing a product so that it provides the same functions with lower material or staff cost without losing any of its value. The function that a product does brings value to customers, and sometimes customers can also see value just in owning a product. If the only thing in a product bringing value is, however, the function, which is typical for tool makers, it is a waste of money to produce it from more expensive material than needed. When a manager tries

to analyze the value of the company's products he/she should consider three things: design, process methods, and purchasing materials or services. (Hill 2000, p. 89-91)

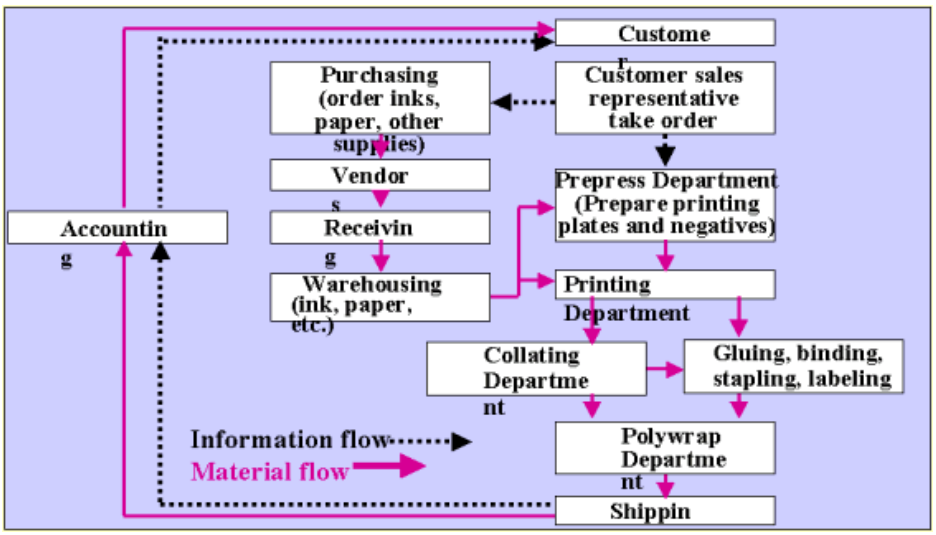
Value stream mapping

Value stream consist of all activities, value-adding and non-value-adding. Value stream map is a drawn map of the whole process from beginning to the end. It can be e.g. description of an assembly or systematic product development showing transformation steps, information flows, key time metrics, etc. Value stream mapping process starts with documenting the current state and barriers to flow. The next step is designing a future state of how value should flow and in the last step a strategy and a plan are made to implement the future state. (Osterling 2009)

In value stream mapping, the concentration should be on one product or product family at a time. Managers, outside eyes, and someone with process knowledge should be involved in the analyzing process. The main goal of value stream mapping is similar with lean; to get rid of the waste, to eliminate the unnecessary non non-value-adding activities, and to optimize the value-adding activities. How often the analysis is made is individual to every company. Monthly, weekly or even daily for processes with long takt times, so it is possible to make corrections before the reporting period is over. (Osterling 2009)

Flow diagrams and time-function mapping

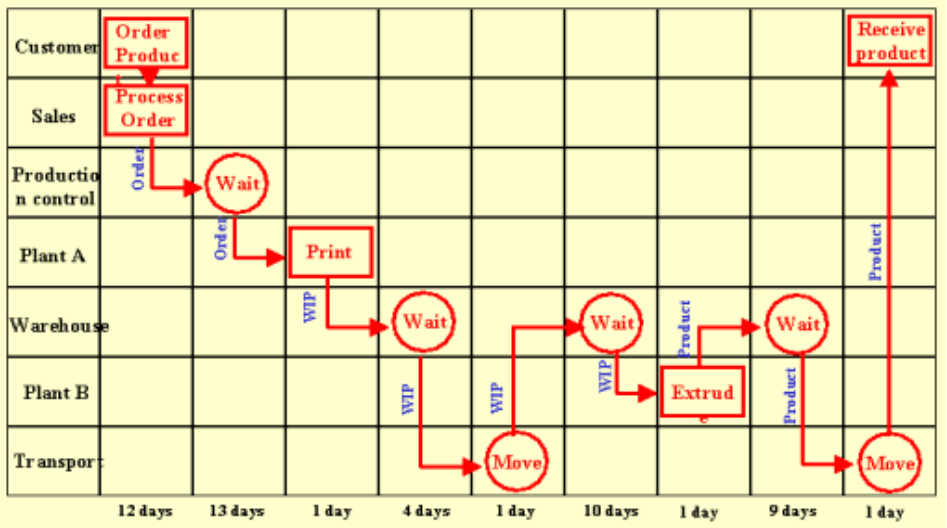
A *flow diagram*, presented in picture 5.7is a drawing or a schematic of material, product, people and information moving in the process. It shows activities in squares and process flow direction with arrows. In picture 5.7 the full line describes material flow and the cut line describes information flow. The tool can be helpful in designing, analyzing, and understanding a process. (Heizer & Render 1999, p. 236)



Picture 5.7 *Example of a flow diagram (Portland State University)*

Time-function mapping is an extension of a traditional flow process chart with time added on the horizontal axis. It can be used to eliminate waste like duplications, extra steps, or delay. (Heizer& Render 1999, p. 236) An example is presented in table 5.2. In this example, the stages of the process are described on the vertical axis and in the table itself are symbols that show what actually happens in every stage. The time here is not a continuous line, but the time that every action takes is written on the bottom of each vertical column.

Table 5.2 *Example of a time-function map (Portland State University)*



Process charts

Process chart is a tool for analyzing and recording the activities that a process consists of. It allows us to see the percentage of value adding work time compared to total time. (Heizer& Render 1999, p. 236) In table 5.3 is an example of a process chart for manufacturing a steel cone, which could be used for example in a crusher. First all the stages of a process are listed under process description. The stages are classified to categories according to what is done to a product or a part in every stage, here operating, transporting, inspecting, delaying, or storing. Then the time for each action is recorded and the measures of the transportations measured. In the end the total time that actually adds value to the product or the part is counted.

Table 5.3 *Example of a process chart, where O = operation, T = transportation, I = inspection, D = delay, S = storage (adapted from Heizer & Render 1999, p. 236)*

Distance in meters	Time in minutes	Chart symbols	Process description
		S	Steel in storage
30	7	T	Transfer to job shop 1
	180	O	Edging
5	3	T	Transfer to job shop 2
	40	O	Welding
	15	I	Testing
7	4	T	Transfer to finishing
	60	O	Polishing
3	3	T	Place in finished goods storage
45	312	1S, 4T, 3O, 1I	TOTALS
	5 h 12 min		Value added time=Operational time/Total time = 280/312=89,7%

Value stream mapping, flow diagrams, time-function mapping, and process charts bring mostly only small improvements and changes to processes. If a radical change that re-thinks the whole process and brings dramatic improvement is made, it is called process reengineering which is similar to business process reengineering described in chapter 5.3.1 (Managing quality). Process reengineering reevaluates the whole purpose of the process, which can result to a conclusion that initial assumptions of a company's processes are no longer valid. Special focus is set on activities that cross functional lines. Managers are often managing a certain function and that is why cross-functional activities and processes can be neglected. But any process can be a candidate for process reengineering. (Heizer & Render 1999, p. 239, according to Hammer and Stanton 1995)

It is easier to develop processes, if they are understood. There is an eight step path presented by Roger Bohn (Slack & Lewis 2011, p. 234-235, according to Bohn 1994) that guides operations managers from complete ignorance to complete knowledge in understanding the process they are managing. In *complete ignorance*, managers have no understanding what is important to processes and the outputs are totally random. In stage two they have *awareness* about the connections between the outputs and the process, but there are no measures or knowledge how things affect each other. Process management is depending on gut feelings and tacit knowledge. Stage three is called *measurement* and managers on this stage have awareness of variables that affect the process. The variables still cannot be controlled in stage three and managers are able to make changes only according to the changes in the variables. In stage four, *control of the mean*, managers already know how to control the means of the variables and can start experimenting. In stage five, *process capability*, managers have learned how to control

the average and the variation of the variables. They can manage and control the processes and already have some rhythm in their management. Stage six is called *know how* and managers on this stage understand how the variables affect the process outputs. They are ready to start making small improvements and optimization for the processes. Stage seven, *know why*, is the level where managers have comprehensive knowledge of the processes and can predict how they will behave in different conditions. The final stage is *complete knowledge*, but in reality managers never get to this stage. Being on the eighth and final stage would mean knowing and understanding every single variable and condition affecting a process. But managers should try to reach this hypothetical stage by considering new variables and conditions and by examining if and how they affect the processes.

5.3.3 Managing human resources

Most of the managers in companies are also managing operations so most of the people in companies work for operations managers. That is why it is important that operations managers know how to manage people too. According to Heizer and Render (1999, p. 366) operations manager's job is to manage labor and design jobs so that employees are effectively and efficiently utilized. Mutual commitment, trust and reasonable quality of work life; equitable pay, safety, and physical and psychological requirements, are important. A good human resource strategy can be expensive and hard to obtain, but it is also hard to copy. That is why it can bring lasting competitive advantage to a company. Many of the other nine operation decisions (Heizer & Render 1999), like location or layout, have an impact on the decisions about human resources (HR) and trade-offs are required in achieving needed quality of work life.

Determining staffing policies that deal with employment stability and work schedules is called labor planning. There are two extreme ends in dealing with stability: a company can fire and hire employees always according to their need or they can keep the employment constant, which means that during low season there is less work per person. For tool makers the second way seems like a better option, because the key to their success lies in the skills of their workers. But of course most of the companies are somewhere in the middle of these ends. In work schedules the traditional way to go is the eight hours five days a week, but nowadays there are some variations. In some companies or positions it is possible to do only four day week or less by working longer shifts on the days an employee actually works. Flextime means that workers can come to work during a certain time period and leave during a certain time period, they just have to keep track that a required amount of hours is filled every week or month. This is impossible if a company wants to keep the machines running 24/7 or if it is necessary to have more than one person at a machine at all times. (Heizer & Render 1999, p. 367) In Finland, one steel cutting company has reduced the overall working time of their employees: they work only six hours a day, but have only one short break. Employees have the energy to work with full power and concentration the whole day and are happy to get home early.

Working in shifts is very common for workers in tool making industry. Unfortunately, according to Mikko Härmä, the manager of the know-how center of Finnish Institute of Occupational Health, working night shifts especially raises the risk of diabetes, obesity, breast cancer, and heart- and vascular diseases. After four or five night shifts a person is so exhausted that they need a few days just to get over it. Then the new week starts again. The best way to organize the shifts is clock wise: night shift is followed by morning shift and after that comes evening shift. This order is adapted from the natural day rhythm and is often used in the tooling industry. Also the predictability of the shifts and considering the wishes of the workers, have positive effects on their motivation and spirits. In Sweden, according to Juha Antila, the development manager of the Central Organization of Finnish Trade Unions, this has been done by letting the workers book shifts that fit to their rhythms. (Manninen 2011)

Job design

The jobs of the employees should be designed so that working will be satisfying and motivating. Satisfaction means that an employee is interested in the job and is committed to the organization. Motivation reflects the desire to do the job well, which can lead to higher performance. Repeating the same simple activity for years is hardly keeping anyone interested or motivated. Operational manager can design a job so that it grows horizontally and vertically as time passes. The traditional approaches for doing so are presented next. (Hill 2000, p. 532)

Job enlargement means increasing the number of operations that one employee is performing and results also in increased skills. With *job rotation* a manager can create work variety in tasks or shifts. For example, in food industry it is essential to have a person at certain points of a production line, but variety can be created by switching the places. *Job enrichment* increases the depth of the job by giving employee more responsibilities. This can mean not telling the employee how to do the job, just telling what is expected as a result. (Hill 2000, p. 534)

Employees can also be motivated by including them in the decision making processes and company development, and by sharing information. Brown et al. (2000, p. 237) suggest that sharing information and communicating ideas through the organization could be done by team briefings, newsletters, videos etc. or by open management. Open management means having no secrets, but really telling the employees if something goes good or bad and why it is happening. They also suggest that employees could be involved as key stake- or shareholders. This would make them work harder, because the success of the company would actually show in their possessions. According to Hill, (2000, p. 540) suggestion schemes or continuous improvement involve employees by giving the employees a platform for their ideas. The ideas can be for example new tools or improving processes and they can bring significant savings to a company and make substantial changes to the ways things are done. There just has to be a clear system of how the suggestion schemes process works. Suggestions must be handled fast and if they are carried out, there should be a reward for the person or group, who made them.

Hill highlights *Quality circles* as another way of including workers into company development. In a quality circle, a group of employees meet, for example, weekly to discus and solve problems that they or other employees face in their work. This is an opportunity to solve the problems themselves instead of just telling about them to already busy managers. The employees taking part in quality circles can get training for problem solving and for implementing change. Heizer and Render (1999, p. 84) claim that quality circles often meet after work and are only awarded with recognition, not financially. This does not sound motivating enough to make the employees to come up with anything worthwhile after a long day of hard work. The opinion of the writer of this research report is that more motivators need to be set for quality circles to get them really working.

Brown et al. (2000, p. 242-243) remind us that teams cannot be formed just by throwing people together. Teams need to be built and sustained. A team has to have clear objectives and tasks, effective leadership, clear roles and a good balance of them, tools to solve conflicts inside the team, and a team has to communicate with the organization continuously. Team members also need to have training on how to work in teams. Well built teams offer flexibility and problem-solving capacity that exceeds what individuals have to offer, and that is why teams are a valuable asset for a company.

"Superior performance is ultimately based on people in an organization." (Gino & Pisano 2008) Gino and Pisano (2008) define a theory of behavioral operations as a study of human behavior and cognition, and their impacts on operating systems and processes. According to them behavior can be included in operations management in prescriptive or descriptive ways. Prescriptive way means that the biases of a decision maker can be corrected with education and feedback resulting as better decisions. Gino and Pisano present a table of possible biases and heuristics in their article including, for example, conservativism, overconfidence, wishful thinking, etc. Descriptive way on the other hand refers to situations where the decision maker is for example a customer, when irrational decision making might be even positive for the company.

The behavior of the employees, their skills and the new ideas that they provide for products, processes, and for ways of working are core competencies for any company. But employee involvement, building teams, sharing information, and building a culture where all this is done on daily bases is hard work. Things change, so no model stays good for ever. But as stated earlier, investing in human resources is worthwhile. Committing to people as strategic resources and building a sense of shared purpose will bring a company towards high performance. Employees need to know how to learn and how to share knowledge and that way how to learn together. Some companies develop habit of learning by offering employees opportunities to learn something non-work related like languages or hobbies. Brown et al. (2000, p. 246-248) claim that in the future, knowledge that the employees and companies have, will be the key to success. Knowledge can be patents and copyrighted materials that a company has, but most likely it is

going to be the knowledge in the minds of people and their behavior, and the knowledge in the ways of working, that matters. (Brown et al. 2000, p. 221-248)

5.3.4 Supply chain management

Suppliers supply tools, parts, raw-materials, subcontracting jobs, and today even labor for tool makers. Supply chains receive attention, because purchasing is a costly activity. A good purchasing strategy is an opportunity to cut costs. Tool makers must demand the same level of quality from their suppliers as their customers demand from them. In supply chain management the goal is to identify what a company needs from the suppliers and to determine the most suitable suppliers for everything. This includes also the make-or-buy decisions, choosing between producing a component and purchasing it from an outside source. (Heizer & Render 1999, p. 419)

According to Heizer and Render (1999, p. 420), there are five different supplier strategies. *Long-term partnership* is usual in the tool making industry, because sometimes there is only one supplier available with a certain technology and it is essential to have a solid partnership. *Negotiating with many suppliers* is used when there are many suppliers available for a certain product and the main issue to negotiate is the price. A company can also use *vertical integration* and actually buy the supplier. A tool maker might be forced to this, if a crucial supplier is about to quit an operation that a tool maker needs. In a combination of vertical integration suppliers can *become a part of company coalition*. And finally a company can develop *virtual companies* that rely on many supplier relationships of their own to provide services on demand. This is a supplier strategy that tool makers can use at the delivering end of their production. Collaboration platforms discussed in 3.1 satisfy the same needs as virtual companies.

Make-or-buy decisions

In theory, it is possible to buy or produce every product or service, but in reality, to achieve competitive advantage, make-or-buy choices have to be made. And the decisions have to support the strategy. Processes that represent the core elements of the business are usually kept in the house. Like assembling cars or making paper. Companies can also have some secret technologies that they do not want to share with outsiders, like Wärtsilä, which cherishes its technique of tightening big bolts. Companies develop new products constantly and new technologies are required to produce them. Sometimes companies find themselves in situations where technologies that a company does not have in the house are needed. This can result to buying components or materials from suppliers. Increased demand for some product or products may force a company to use outside suppliers as additional capacity. (Hill 2000, p. 402-404) Tools makers can also face a situation like this when orders on hand are numerous. They might order extra machining work from partners to be able to deliver all orders on time.

The principal reasons of make-or-buy decisions are presented above, but in everyday life the decisions are often made for other, less rational reasons. For example, the way something has been done for a long time can just seem like a good way of doing it

and a make-or-buy decision is not reconsidered. It requires a lot of time and energy from a manager to start thinking about a decision from the scratch again. (Hill 2000, p. 404)

There are of course plusses and minuses on the both ends of every make-or-buy decision. When a company integrates vertically or decides to rather make than buy, it collects new knowledge and know-how resulting to new competitive advantages. With new technology know-how a company can also come up with technological innovations and a company can become less dependent on certain suppliers. On the contrary, benefits of buy decisions usually concern cash, costs, and technology. It is cheaper to let someone else produce a part with a new technology than to get the technology for yourself and train the employees to master it. It is easier to control the costs, when someone else has to worry about keeping the technologies up to date and a company has more capacity to focus on its core tasks. (Hill 2000, p. 405-407)

Supplier selection

In selecting suppliers Heizer and Render (1999, p. 425) recognize three steps: evaluation, development, and negotiations. In many cases, one supplier is obviously superior to the others and evaluation of many suppliers is not needed. When this is not the case, a weighting system can be used to help make the decision. First the criterion, which will be weighted, has to be agreed on. Second, every criterion has to be weighted to reflect the level of importance to the company, and third, each potential supplier is rated on every criterion. The sum of rating points shows the best option. Before doing the weighting analysis, a company can get to know the potential suppliers, for example, by visiting their sites. Seeing the technical capacities, management's know-how and attitudes, operations capacity, and many other things of the supplier will help to rate the criterion in the weighting analysis. (Hill 2000, p. 426)

The current trend is to go towards fewer suppliers and towards deeper, long-lasting relationships between a company and its suppliers. This allows companies to invest on developing their suppliers. Development can include for example training, engineering or production help, or formats for electronic information transfer. These are actions that make the suppliers meet the needs of a company better. (Heizer & Render 1999, p. 426)

Heizer and Render (1999, p. 426) introduce three different negotiation strategies. In *cost-based price model*, the supplier has to share some information with its potential customer, because the contract price is based on time and cost or it can be a fixed cost with an escalation clause for covering the changes in the supplier's costs. *Market-based price model* simply places the price on published price or index. *Competitive bidding* is basically same that *negotiating with many suppliers* mentioned earlier, and is a typical negotiating tactic in many companies. It is also possible to combine different negotiation techniques.

Multi-criteria decision making approaches

Ho et al. (2010) write about using multi-criteria decision making approaches in supplier evaluation and section. There are many different methods that fall into this category: analytic network process (ANP), analytic hierarchy process (AHP), case-based reasoning (CBR), data envelopment analysis (DEA), fuzzy set theory, genetic algorithm (GA), mathematical programming, simple multi-attribute technique (SMART) and probably even more. What is in common for these methods is that they all use some kind of programming. Some indicators are weighted and inserted to a program which counts out the result of what decision would be the best in the situation. Multi-criteria decision making approaches can also be used to evaluate answers to other questions than supplier selection. In this thesis, however, they are not presented in detail, because that would be a whole other thesis in extent.

5.3.5 Inventory management

Inventories can hold a large share of company's capital and are a vital part in keeping the production flow continuous, what makes them worthwhile to monitor. Often inventories do not get the attention they need, because managers are more concentrated, for example, on purchasing. Inventory management is the kind of silent, day to day management where as purchasing always needs investment and new equipments always draw attention. Often a problem has to occur in the inventory before it starts to draw attention. It is not easy to notice, if there is too much of something, but too little of something is immediately detected. What belongs to the inventory? A company owns facilities, machines, tools, parts, raw materials, etc. But fixed assets are not a part of inventory, only the items and materials that are constantly purchased and consumed are a part of it. This includes the items and materials used to manufacture the products, the compressed air and gasses for keeping the machines running, and also the office articles inventory. (Hill 2000, p. 363)

Inventories are usually divided into two different kinds; corporate inventories and operations inventories. Operations inventories help operations to do its tasks and corporate inventories provide advantages to other parts of an organization. Corporate inventories hold usually 20-25 percent of the total inventory and operations inventory 75-80 percent. These inventory types are explained later with the *causal analysis*. (Hill 2000, p. 366-367, 387)

The numbers in the financial data are not the same as inventory control. Control systems for inventories need to be developed for every inventory in the company. This can be challenging, because there are often many opinions about how large inventories should the company keep. The questions that need to be considered when planning inventory control system are: when and how much to order, what items to hold in stock and how many, and how to carry out the inventory count. Tool makers usually operate based on customer orders; they have a make to order (MTO) strategy. Customer orders often trigger ordering parts and materials. Orders on hand can be numerous and the production can be scheduled far ahead. The sizes and starting dates of the orders answer to

the questions when and how much. Some common parts and materials that are used often can be kept available at all times. For these materials the ***economic order quantity*** can answer the question how much. It aims for the lowest total cost of inventory holding. The formula of economic order quantity is given below.

$$EOQ = \sqrt{\frac{2zC_s}{\mathrm{cC}}}$$

where z = total annual usage, C_s = cost of placing an order, c = unit cost of an item, and C = carrying cost per year. The formula makes some simplifying assumptions, like that the rate of the demand stays constant, that the costs remain fixed, and that the capacity of operations and inventory is unlimited. Regardless of these assumptions, the formula gives useful guidelines for making decisions concerning the how much –questions. (Hill 2000, p. 376-381)

Inventories can be controlled with *continuous review system* or with *periodic review system*. Continuous review means monitoring stock position after every transaction. At some check the stock position reaches its reorder point and a fixed quantity is ordered. This is often done with the help of computers and ERP-programs, for example SAP that is gaining more and more users in the markets nowadays. Despite of the modern systems, reviewing after every transaction is still time consuming and expensive. In periodic review system, the stock positions are reviewed at fixed time periods. The reorder point is the point where there is still enough in stock to cover the production until the next check and over the delivery time. Examples of supplementary systems for periodic view are single-bin and two-bin systems that can be used for example for screws and bolts of which big amounts are consumed every day. In single-bin system a "bin" is filled up periodically and in two-bin system a new "bin" of items is ordered when the first "bin" gets empty and the second is opened for use. The systems can all be in use in one inventory, because different kinds of items need different kind of controlling. Expensive items can be controlled with continuous reviews and cheaper ones with cheaper methods. One ground for placing a reorder is the point in which the economic order quantity is required. (Hill 2000, p. 387-389)

According to Heizer and Render (1999, p. 443), there are two important things to consider in inventory management; how to classify the inventory items and how to keep an accurate inventory record. An answer to the first question is given next, causal analysis examines inventory clusters, and accurate inventory record is discussed after that.

Classifying inventory items

In ***ABC analysis*** the products are divided into A-, B- and C-classes following the Pareto principal "critical few and trivial many" discussed already in chapter 5.3.1 (Managing quality). In inventory management, the inventory items are divided into A-, B- and C-

classes by measuring *the annual demand* of each inventory item times *the cost per unit*. This value is called annual requirement value (ARV). Items that have high ARV belong to A-class. These items represent 70% to 80% of the total inventory costs, but usually just 15% of the items. In B-class are inventory items with medium ARV, typically about 30% of the inventory items and 15% to 25% percent of the total value. The rest, about 55% of the items, have low ARV and belong to C-class representing as less as 5% of the total value. In inventory management, the goal of an ABC analysis is to establish inventory policies, like inventory counts discussed in previous paragraphs. The inventory policies focus the resources on the few critical items and not on the many trivial ones. This requires checking the ARV values and the control levels on certain time periods. (Heizer & Render 1999, p. 441)

Another way of classifying inventory items ***is the principle of independent and dependent demand***, which divides the products into two categories. Products with independent demand are the final products or parts and services that are not linked to the demand of any other items. Dependent demand items depend on the demand of final products or services and are the components or materials needed in producing a product or a service. In other words, the number of independent items is known or has to be forecasted where as the number of dependent items can be calculated. For example, how much steel is needed depends on what kind of and how many tools are ordered. (Hill 2000, p. 372)

These two methods do not bar each other out; they can be used at the same time, because they classify items for different purposes. ABC tells on which items is it most valuable to concentrate in inventory management whereas independent/dependent demand principle focuses on how to find out how many of the items or how much raw material is needed to satisfy the demand that ultimately always comes from customers.

Causal analysis

With causal analysis it is possible to identify the clusters of inventory in the operations process. The analysis can be made piece by piece without the whole inventory being observed at the same time. Causal analysis starts with asking why this part of inventory is there. The answers are categorized into:

- Corporate inventories such as
  -*Sales inventories* to support customer agreements or sales inventories owing to actual sales being lower than forecast sales.
  -*Corporate safety inventory* due to the uncertainty of supply.
  -*Marketing inventory* to support product launches.
  -Etc.
- Or five functions of corporate inventories
  -*Decoupling inventory*, some machines or work stations do their tasks faster than others. Decoupling inventory helps to ignore this conflict by storing parts between the machines or stations, so that the production can flow smooth no matter what.
  -*Cycle inventory* varies with lot size.

-*Pipeline inventory*, when a company decides to subcontract one process to an outside supplier, all the inventory associated with this decision is classified as pipeline.

-*Capacity-related inventory* enables transferring of work load from a busy sales period to a low sales period by storing ready products to be sold later.

-*Buffer inventory*, when the demand exceeds the average, buffer inventory will help a company to cope with that. The same technique is also used for changing level in supplier availability.

The place in an operations process is also defined for all the inventories; where the inventory was last processed and what is the next step. If there are more possibilities, the value of the inventory is split between them. This builds up a picture or a map in which the clusters can be seen. Changing of the rules of why inventories are allowed to be made can lead to fewer inventories and less costs. (Hill 2000, p. 366-370, 390)

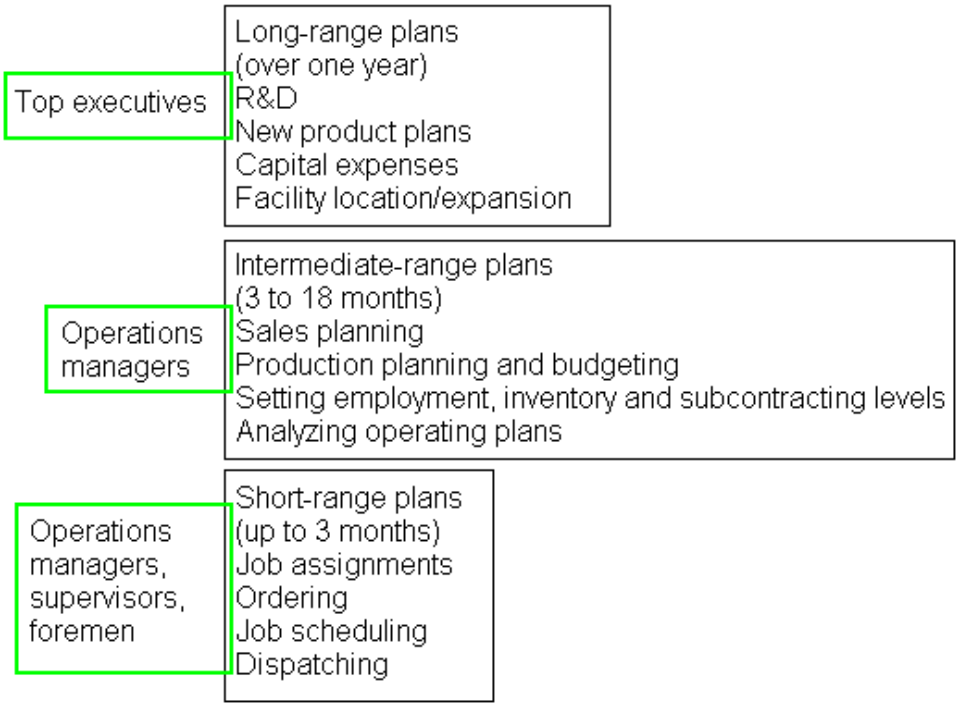
Accurate inventory record

Inventories work only if the right people have the right information about what the inventories hold. Purchase needs to know when to order new materials and managers need to know what materials are on hand to schedule production. Stockrooms have to be well organized, only the people trained for the inventory maintenance job should have access to them, and incoming and outgoing records must be kept accurate and on real time. Every inventory is checked every now and then for mistakes in the records. Some companies do this annually with a group of outside workers. A better way is to use the inventory employees that the company has trained. This can be done with cycle counting which also does not require the company to stop production for the time of the inventory. Cycle counting uses the results of ABC analysis for determining how often every item should be checked. A-items can be checked for example once a month, B-items four times a year and C-items twice a year. The mistakes in the inventory record are documented so the causes behind them can be examined. (Heizer & Render 1999, p. 443-444)

5.3.6 Scheduling

Long-range plans that aim for goals in more than one year, like strategy, belong to the responsibilities of the top management as it can be seen from picture 5.8. Operations managers have the responsibility to schedule the actual production, which usually means planning it from 3 to 18 months ahead (intermediate planning) and to design job assignments and other short-range plans with supervisors and foremen. Intermediate-range planning is also called aggregate scheduling or planning and the tasks of it are described in the middle box of picture 5.8. Aggregate scheduling needs to be done so that it follows the strategy of the company. A target for aggregate scheduling can be, depending on the strategy, for example the lowest possible costs, driving down inventory levels or keeping the employment level stable. Aggregate scheduling, according to its name is also a plan of how many products in total is a company going to produce over a certain time period. For aggregate planning, forecasting and capacity planning informa-

tion is needed to succeed. Forecasting demand is a responsibility of top management and affects capacity planning, which needs to be done before scheduling. Forecasting and capacity planning are discussed shortly later in this chapter. Operations managers receive information from many other sources as well. Financial data, personnel, and availability of materials all influence aggregate planning. In a manufacturing environment, the aggregate plan breaks down into master production schedule. In tool making industry master production schedule tells which tools or orders are manufactured when.



Picture 5.8 *Planning tasks and responsibilities (adapted from Heizer & Render 1999, p. 505)*

Operations managers are also a part of designing the short-range plans, belonging to the master production schedule as well. These include weekly, daily, and hourly schedules about who is working on what. (Heizer & Render 1999, p. 504)

One goal for aggregate scheduling is to meet the demand. This can be done by influencing capacity of the company or by influencing demand, in other words, customers. Capacity can be influenced by changing amounts of inventories. During a low season it is possible to produce products for selling them during high season. The other end is changing the size of the work force by hiring and layoffs. Overtime and idle time can be used as well. Subcontracting or part-time workers can be a solution too, but they require a company to share its secrets with new people and it is not always sure that these people have the required skills to perform. Demand can be influenced by advertising, personal selling, promotions, and price cuts. Back-ordering during high seasons means that a company accepts an order even if it does not have capacity to produce it right away and delivers it at a later time. Companies can also try to solve the seasonal prob-

lem with a counter seasonal product mix, which means that a company has its own products for example for winter and summer. Most companies choose to use a mix of these strategies to meet their demand. (Heizer & Render 1999, p. 507-511)

Heizer and Render (1999, p. 511-518) also introduce methods for aggregate scheduling and for finding the right mix of strategies presented above. With graphical and chart methods an operations manager can visualize the changes of demand and the different ways for meeting it, so that they are easy to understand. There are five steps in using graphical methods:

1. Determination of demand in each period.
2. Determination of capacity for regular and overtime, and subcontracting each period.
3. Determination of inventory holding costs, hiring costs and layoff costs.
4. Determination of a company policy that applies to the workers or to stock levels.
5. Developing alternative plans and examining their costs.

This is a kind of iteration for finding the best possible aggregate plan. In the end the alternative plans are compared with each other to find the one with the lowest cost. With simple graphical methods, it is not possible to create strategies, but they help in evaluating them. There are also mathematical methods that use linear programming and can, because of that, consider more indicators at the same time. These methods are not however widely used. Maybe because of their complexity they are not easy to understand or maybe managers find that with traditional methods they can make decisions faster.

Forecasting

Short-range plans typically do not need forecasting, because what is going to happen in the next three months is usually clear. But forecasting is useful for aggregate scheduling. With forecasting what is going to happen in the future, companies are also trying to minimize these risks that are always included in business. Companies are typically trying to forecast three different types of things: economics, technological changes and development, and demand. Forecasts can be based in the instincts of a top manager or they can be mathematical, summing up the past events to count what is likely to happen in the future. Forecasts are rarely one hundred percent accurate, but they can give companies directions about which way it should go. Short-range forecasts are used for planning purchasing, scheduling, workforce levels, and production levels. Typically, the time for them is less than three months. Medium-range forecasts vary from time range of three months up to three years. They are used in planning sales, production, budgets, and for analyzing operations. Long-range forecasts are used for planning new products, facility locations or expansions, and research and development. Long-range forecasts are usually for three years or more. (Heizer & Render 1999, p. 142-143) Basically, forecasting belongs to the top managers, but scenario analysis, a response to the poor performance of forecasting techniques in the 1950s (Fuller-Love et al. 2006), is easy to understand. It can also be used by operations managers for weighing the different options or scenarios of aggregate scheduling. Scenario analysis is presented next.

Scenario analysis

Simplified, scenario analysis means defining the different future scenarios: what could happen and what can go wrong? In scenario analysis, intuitive knowledge in an uncertain situation is turned into clear research questions that can be explored by system analysis and forecasting (Chang & Luo 2010). According to Fuller-Love et al. (2006) scenarios can be exploratory or anticipatory. Anticipatory scenarios are based on examining a path of past events and to what kind of scenario they might lead up to. Exploratory scenarios examine the important driving forces and the future trends. Exploratory scenarios can help in forecasting and planning, while anticipatory scenarios are more useful in promoting the flexibility of an organization. The ultimate task of scenario analysis is to evaluate the strategic options against the chosen scenarios.

Capacity planning

Capacity planning is a vital part of scheduling. It is related to different planning tasks in all of the boxes in picture 5.8. For example the available capacity is vital knowledge for planning sales, expansions or just scheduling different tasks between the units. Capacity is the number of units or the amount of material that a company can produce in a certain time period, per year, per month, per week, or per day. Effective capacity or utilization is the percent of capacity that a company actually uses. Using 100 percent will drive a company to its limits and can be challenging in case something goes wrong. Efficiency can be counted by dividing the actual output with utilization. Total capacity of a company is hard to change, because equipment and processes are expensive to change, but planning effective capacity for a certain time period has some leeway. Capacity planning decisions concern the quantity of how many products are made and also how they are made. In tool making companies there are often several ways a product can be produced; in what order the parts are made and who makes them. Because employees or work centers mostly have several skills, it is possible to choose who does something. *Break-even* analysis analyzes the different options by dividing the *additional setting-up time* with *reduction in process time per unit or product*. (Heizer & Render 1999, p. 246; Hill 2000, p. 168-213)

5.3.7 Maintenance

Maintenance means maintaining the capability of a system. This includes repairing machines when they break and preventing breakdowns with inspections, keeping the machines in good shape, and designing systems that allow all this. (Heizer & Render 1999, p. 666) Many other operation tasks have an effect to maintenance. With the right design and purchasing the maintenance costs can be decreased and the effectiveness of maintenance increased. (Hill 2000, p. 446) In this chapter the different types of maintenance and the options that a company has to deal with them are discussed.

In maintenance, it is important to analyze when a system is likely to fail. Mean time between failures (MTBF) is used for analyzing when the next failure is likely to happen.

If a MTBF distribution of a machine does not show much deviation, the machine is a good candidate for preventive maintenance. Even if a MTBF distribution shows much deviation, a machine can be a good candidate for preventive maintenance; sometimes the breakdown costs are so big that a breakdown should be avoided at any cost. Also indirectly related costs must be included in the breakdown costs: how does a breakdown of a machine affect other production, employees' motivation, delivery times, and customer relationships and satisfaction? Some processes are, however equally expensive to repair than breakdowns. In these cases it can be more reasonable to wait for the breakdown to happen than to prevent it. The fact how expensive it is to repair processes or machines in case of a breakdown also puts them in a priority order. The goal of maintenance is to keep costs as low as possible, so the most costly repairs are being avoided with the most effort. When the costs of preventive maintenance grow, the costs of breakdown repairs go down and vice versa. An operations manager needs to find the balance between these two costs that creates the lowest total cost. Record of maintenance actions is a good tool in finding this balance and analyzing the need of preventive maintenance for each unit. History can tell approximately how long the mean time between failures is and what kinds of failures are likely to happen. Companies can have records in computer databases and they can use programs and algorithms for counting the lowest total cost. (Heizer & Render 1999, p. 666-673)

Companies should always have some repair capability of their own, because in reality preventive maintenance cannot reach 100 percent. Repair capability inside the company gets the processes back to operating fast and the employees can be trained to become experts in repairing the exact machines that the company has. Some repairs cannot be done in the company's own facilities. Some equipment breakdowns require sending them back to the manufacturer, or taking them somewhere for repair. In these cases managers have to decide where to repair. Sending equipment to the manufacturer for repair usually means higher competence of the repair work, but also more time and total costs. (Heizer & Render 1999, p. 675) Companies can also deal with maintenance requirements by using external personnel that is permanently located at the facility or goes there when needed. Many big companies do this with their computers, printers, and other IT-equipments. They can lease the IT-equipment and have an IT-support department at their location that deals with all the problems with the IT-equipment. This way they have always the newest technology and well trained people to take care of it without training their own employees for the special maintenance tasks. With operations processes the decisions are more difficult. Sometimes a company is forced to use external personnel, for example, when a machine is too big to be moved and when internal personnel does not have know-how on how to repair it. Often companies want to build their internal skills and train their maintenance personnel. (Hill 2000, p. 454)Employees actually working on the machines can be made responsible of some maintenance actions at their own working stations as well. Repairing machines can be too much, because that would need training them all to become maintenance personnel of some level, but for example cleaning, checking, and observing are already a part of maintenance. Managers

must analyze the best combination for every situation. The maintenance plan with lowest total cost can include external and internal maintenance personnel, preventive and breakdown maintenance, and sending some equipment or parts back to the manufacturers. (Heizer & Render 1999, p. 675)

Heizer and Render (1999) talk only about preventive and breakdown maintenance, but Hill (2000, p. 449-452) adds some other approaches to the equation. According to Hill also condition-based maintenance, stand-by equipment, corrective maintenance, and equipment upgrades are a part of maintenance function. Condition-based maintenance is a type of preventive maintenance, but it is based on knowledge of the condition of an item or a machine that systematic inspections result. It tells if maintenance tasks should be performed later or earlier than scheduled. Where the cost or risk of breakdown is extremely high, can stand-by equipment be used as a part of a maintenance plan. This enables the repairs to be made during the normal working hours without interrupting the production. Stand-by equipment require, however, large investments and are not, therefore, so common for the production machines. This approach is often used for support services like water, compressed air, gas, and control units. Corrective maintenance means making improvements to the existing equipment and machines so that the failures do not occur anymore or that they no longer matter. Corrective maintenance includes changing the design of a machine and it is done additionally to the other maintenance tasks. Equipment upgrades are also a part of maintenance. The goal of an upgrade can be to make a process more reliable or to make repairs easier to do. A maintenance record can tell which machine should be upgraded. An upgrade can also involve upgrading a machine to master a new technology, or, for example, give it more throughput speed.

Sudden, surprising failure is more difficult and expensive to handle than failures that can be predicted, like wears and tears. Hill (2000, p. 455) suggests that items can be replaced individually or in groups. Group replacement concern groups of low-cost items that are likely to break at certain time periods. There are different group replacement policies: changing all items of a group periodically, changing failed units when they fail and all units periodically, changing just failed units when they fail, or changing failed units periodically. The criticalities of the items will determinate which policy is chosen. For example, most likely a group of light bulbs have a different level of criticality than a group of drilling heads. The next three factors can also help to make the decision: initial failure period, normal expected failure period, and the wear-out zone if an item lasts longer than expected.

Total productive maintenance is a concept inspired by total quality management. It brings total quality management to maintenance by binding the strategic view to it and by starting with the design and purchase of the machines. Machines should be designed so that they are reliable, easy to use, and easy to maintain. In a case of a breakdown maintenance should be able to repair a machine without dissembling the half of it and parts that need more frequent changing should be reached easy. When purchasing new machines or equipment the total cost of ownership should be evaluated; service and

maintenance costs should be added to the buying price. Managers should develop preventive maintenance plans with the maintenance workers, which would utilize the best practices. Total productive maintenance also includes training employees to operate and maintain their own machines, for example, cleaning, checking and observing as stated above. Heizer and Render suggest simulation and computer programs or expert systems for establishing maintenance policies. (Heizer & Render 1999, p. 675-676)

5.3.8 Improving operations

Developing and improving different operations tasks have been discussed in the previous chapters. This chapter concentrates more on managing the culture of change and on what frequency should the improvements be made.

Every operation decision should be made so that it improves operations, but there are also clear improvements; smaller continuous changes to operations processes and bigger changes concerning for example capacity or supply network. Small and big improvements differ quite radically from each other and need different ways of managing. Slack and Lewis (2011, p. 217) call small and big improvements continuous improvement and breakthrough improvement. Breakthrough improvement s often based on innovation. It changes how operation works, has great impact, and is most of the time expensive to carry out. Continuous improvement means small steps following each other. They are easy to make and continuous improvement should be the natural way of working. Making some improvements, for example, every month keep the culture of change alive. Both breakthrough and continuous improvements should be done in a company, although they should not be done at the same time. Breakthrough improvements can take all the time and energy of a manager and employees and continuous improvement at the same time would just be carried out without any concentration. Sometimes it is not clear if an improvement is continuous or breakthrough, according to another classification by Slack and Lewis there are also some that fall in between. Modification is basically continuous, pioneer change means breakthrough improvement, and extension and development are somewhere in between. Bigger improvements are always harder to manage, but small improvements need managing too, only different kinds.

Another way to look at improvements is that they are a constant way for supporting the markets. Improvements come from market needs and desires, and markets are influenced by improved suppliers. This way of thinking claims that the direction for improvements comes from the markets. And the continuous cycle with the markets also gives a company targets. For example, markets desire faster deliveries or better delivery systems. Some kind of performance measurement is needed to guide improvements and to express the targets clearly. Typical performance objectives are quality, speed, dependability, flexibility, and cost, which can be put together for customer satisfaction or productivity. With these objectives targets can be put into numbers, for example, that 95 percent of the deliveries should be on time before the end of the year. These performance measures alone do not give much information, but they can be compared with

the past values, the future targets or with competitors' numbers. There has to be a link between strategy and important performance measures, because everything in a company cannot be measured. That would be a waste of time and resources. The link is how to decide what to measure. (Slack & Lewis 2011, p. 220-225) Next, some approaches and techniques for operations improvement are presented.

Benchmarking

Benchmarking is one very popular way for improving operations. The idea of benchmarking is to compare operations with competitors' equal operations, other operations that perform extremely well in the company or in another company, or with non-profit organizations, and to learn from them. The ultimate goal is to find the best practice (Hill 2000, p. 503). With benchmarking companies can evaluate how well their operations are doing and set realistic performance goals. It is also about searching for new ideas of how to do something. It can be impossible to go into competitor's factory to see how they are doing something, but good ideas, for example, for customer service can be found in companies on the other fields as well. Benchmarking is also a process in which companies have to examine their different parts and learn to understand external customer needs and what processes are used to satisfy them. (Slack & Lewis 2011, p. 225-227)

For successful implementation of benchmarking a company has to set the targets high enough and review them continuously. The company has to believe in the benchmarking process. Better solutions are hard to find if a company thinks that their one is the best. But there is always something to improve so companies can always do better. Everyone needs to be involved in checking, identifying and implementing the changes. (Hill 2000, p. 503-504)

The different types of benchmarking are called non-competitive, competitive, performance and practice benchmarking. *Non-competitive* refers to benchmarking where the company compares its operations against companies that compete on different markets. *Competitive* is benchmarking where the comparing is done with direct competitors. *Performance* benchmarking means that operations are benchmarked against each other with performance objectives. And finally *practice* refers to benchmarking, where practices of different operations in an organization are compared with each other and some are being adapted to other operations. (Slack & Lewis 2011, p. 226)

Importance-performance mapping

Importance-performance mapping is an approach for directing operation improvements. It brings together the needs and preferences of customers and how well the competitors are performing. In this approach, these two things are called importance and performance, and they should be judged together for deciding what should be an improvement priority. Customers' importance priorities do not necessarily mean that those operations should be improved. It can be that the operations are already doing much better than the

competitors' equal ones. And quite the fact that competitor's equal operation is doing better does not necessarily mean that the operation should be improved.

The results of importance and performance evaluation can be collected into a matrix like in picture 5.9. On the horizontal axis is the importance for customers and on the vertical axis the performance against competitors. Operations or the competitive factors of operations are placed in the matrix and it is divided into four sections. Operations in the urgent action -section are in a critical state and are clearly an improvement priority. They are performing badly, but are important to customers. This probably results straight as losing business and performance needs to be improved quickly. The operations in the improve-section also need improvements like any operation under the appropriate-section, but all of them are not as critical. Operations right under the line or operations in the left corner need improvement too, but are not priority, because either they are almost appropriate or they do not matter that much to customers. Operations in the appropriate-section are performing on an ok level at least on short or medium time range. Every improvement should raise an operation at least to this level, but the ultimate goal is of course that all the operations would be in the highest, excess-section.(Slack & Lewis 2011, p. 227-229, according to Slack et al. 2010)

Picture 5.9 *The importance-performance matrix (adapted from Slack & Lewis 2011, p. 228)*

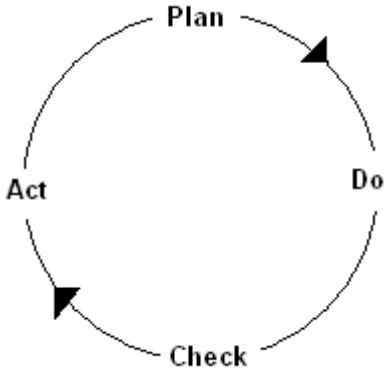
The sand cone theory

The sand cone theory claims that there is the best order in which to improve performance objectives of operations and that it should be done cumulatively. The first performance objective to focus on is quality, because it is the base for all improvements. The next step is to concentrate on dependability, but without forgetting quality. They

both should be thought of in the second phase. In the third phase speed is added to the first two. Improvements should now be made to quality, dependability and speed. The fourth performance objective would be flexibility, because speed in reacting to new customer demands or speed in setup times comes from flexibility. Further improvements should still be made to quality, dependability and speed too. In the final, phase cost improvements are added to the mix. (Slack & Lewis 2011, p. 231)

The Deming cycle

The Deming cycle, also called the PDCA cycle (plan-do-check-act) helps to identify opportunities for continuous improvement. As picture 5.10 shows, it starts from the plan-step, where a problem is identified, or a process or an operation for improvement is chosen. Researching and examining all the aspects of the chosen problem and coming up with a plan of how to improve it belong also to the plan-step. Do-step means implementing the plan, giving the training needed for achieving the needed new skills and making everybody involved so that everybody would accept the improvement and to commit to it. Check-step means checking the results of the improvement. Finally in the act-step all the information is gathered together and evaluated for finding any needs for corrections. In this step it should also be made sure that the improvements are maintained and the employees do not slide back to the old ways of working. The philosophy behind the word cycle is that the Deming cycle is never ending like continuous improvement should be. By making the endless rounds in the cycle a company is making continuous improvement. (Hill 2000, p. 508-509, according to Deming 1986)



Picture 5.10 *The Deming cycle (adapted from Hill 2000, p. 509, according to Deming 1986)*

Why-why reviews

Why-why reviews are a simple technique with which it is possible to get to the bottom of any problem and identify its causes. It is similar with the fishbone technique presented in chapter 5.3.1 (Managing quality). Why-why review starts with asking why a problem occurs and writing down the answers, in other words the reasons for it. The next step is to ask every single reason why it occurred. The answers are written down

again and every answer is asked why again and so on. Like this a problem is broken down to small pieces and some of them might be very easy to fix. Why-why reviews can have as many rounds as the maker of them wants there to be. (Hill 2000, p. 517)

"Improvement does not end with implementation." (Hill 2000, p. 520) This can be seen in the Deming cycle as well as in the popularity of continuous improvement all over the literature and work places. The process of improvement never ends. Many methods for improvement have been around for a long time, but new trends can be seen in how they are used. The methods and tools a company decides to choose for improving its operations have to form a package. They cannot be just a set of separate tools, but they have to complement each other. People that the improvements concern need to be involved in planning, implementing and maintaining the improvements and all the employees of the company need to be committed to the idea of continuous improvement. (Hill 2000, p. 520-522)

5.4 Summary

How to analyze, manage, improve, and implement operations? The answer to the first research question has now been given and this chapter sums it up.

The key that every theory and technique highlights is communication. In analyzing, managing, improving or implementing a strategy, business model or operations, communicating what is done and why throughout the whole organization is the key to success. Communicating does not mean posters on the walls with slogans, it means educating employees about how their work is a part of achieving whatever the company is trying to achieve. Another key is flexibility. Companies have to be able to adapt to the changing environment and for toolmakers job shops as an operations system can bring the needed flexibility. Continuous improvement is also highlighted by many authors. It includes employees in the improvement processes and this way increases their flexibility and ability to adapt to other changes as well. The culture of change is developed. Eliminating waste is a trend that can be seen in the popularity of lean thinking, and it is a good philosophy. Companies just have to watch that they do not take this trend too far and cut operations that are helpful in creating value although do not directly create it themselves.

How to analyze the current position of a company? There is no simple answer to this question. Business is a package in which every part influences its performance; it has to be analyzed as a whole. A business analysis based only on numbers, such as financial data, can give a false picture of a company and how well it is doing; facts like out-of-date products do not show in numbers. All of the operations tasks discussed in chapter 5 can have a significant impact to the profitability and different kinds of methods are needed for analyzing, managing, developing and implementing them, although, some tools and techniques can be used for more than one purpose.

6 SUGGESTIONS FOR FUTURE RESEARCH

The second research question for this thesis was to search for a gap: Is there some part of business that does not yet have an analyzing method? For which business area should a new method be developed in tool making industry? The methods that are already available are presented in chapter five (Into operations). Many business areas have a large amount of different techniques for analyzing, developing, managing and implementing them. These areas are not the ones where a gap can be found. All the knowledge produced by the new analysis models should help to solve the problems of the customers' or make the working in a company easier in some other ways. As the analysis continued, it became clear that some areas are more meaningful for tool makers. These areas are presented next as answers for the second research question.

All of the methods, tools, techniques that are presented in this thesis were gathered into an excel chart (appendix 1). From examining the chart it can be seen that clearly the themes that have been trendy in the management fields have more methods than the others, for example quality. This indicates that for developing a truly new method, a new field should be defined as well. Chapters 6.1, 6.2, and 6.3 give some examples of what this new field could be.

6.1 Skills

The skills of the managers and the employees in the tool making industry are an important competitive factor in the research materials. Skills can be a critical success factor for a tool maker. Skills of human resources are also one of the basic points of views of the balanced scorecard (4.1.4, Kaplan & Norton 1996). As discussed earlier, Hill and Deming claim that everyone in the company should be encouraged to educate themselves and to make self-improvement (Hill 2000 p. 313, according to Deming 1986). What could be a better way for this encouragement than an accurate analysis of the skills needed in tool making and an analysis of the skills that a tool making company already has. But how to analyze what skills a company needs and what skills it has? Can this be done with some kind of know-how matrix? And how to get the skills needed in tool making industry?

Some ideas for analyzing the skills of the managers could rise from the eight step path from complete ignorance to complete knowledge by Roger Bohn (Slack & Lewis 2011, p. 234-235, according to Bohn 1994) presented in chapter 5.3.2 (Analyzing and developing products and processes). When developing an analysis model for the skills, it should be recognized that improving the skills should be a never ending process like the process in the Deming cycle in chapter 5.3.8 (Improving operations) or like the last

step in Crosby's quality philosophy: 'do all the steps again from the beginning' (5.3.1 Managing quality). Organization should learn new ways to work which means that all the employees and managers in the organization should learn to forget the old ways of working and adapt the new ones (Ruohotie 2000). In analyzing skills, this aspect could also be considered: How to analyze how well people in an organization are able to move forward in adapting the new ways of working? How does an organization produce new knowledge?

6.2 Service functions

Like stated in chapter three, even the tool making industry is moving towards more services which is the current trend in many industries. In the next few years the development of the product related services seems to be vital, which fits to the customer point of view of the balanced scorecard (4.1.4, Kaplan & Norton 1996) and to lean fourth element of lean thinking; customer focus (5.3.1, Slack & Lewis 2011). Tool makers need to offer complete packages including products and services like said in chapter 3.1 (The current state of the industry). The business model theory that the research group chose is presented in chapter 4.3.1 (Creating a business model). "How do I win, nurture and keep the customers?" ask Lechner and Müller-Stewens in this theory. This question can be answered by analyzing the service function.

One reason to analyze the service function is to get more information about the change impulses that affect the customer and through customers also the tool maker. This helps the tool maker to forecast the impulses that come from the markets of their customers. One question is what does service actually mean in tool making industry? Does it include only services related to delivery or also the services related to the maintenance actions? If a model for analyzing services in tool making industry was developed, should it also measure the level of the services?

Tool makers also need to understand the industries in which their customers are working like stated in chapter 3.4 (Managing tool making). Could there be a method which would analyze or develop this understanding? What would be the sectors of the customer industry that a tool maker should know and understand? In my opinion, at least how well educated the people are that will be working with the tool in making, what kind of materials will the tool be handling and how do the materials behave in the conditions of the customer factory, and in what kind of environment will the tool be used in; safety comes first.

6.3 Platforms

For tool makers the fact that the customers are often far away causes challenges. Tool makers in Europe are competing with the cheap labor costs in the far-east and they are, like every other industry as well, trying to find new ways to stay more tempting as the low-cost competitors from the far-east. *Collaboration platforms* were given as a tool for

fighting these challenges in chapter 3.1 (Schuh et al. 2010).In the management point of view the forming of collaboration platforms clearly changes the processes and managers need new analyzing models for decision making on the European platforms. In Balanced scorecard one of the management perspectives is the process management (4.1.4, Kaplan & Norton 1996). Collaboration platforms are complicated networks, where many different companies are trying to co-operate on some level. Collaboration platforms unite the knowledge of co-operating companies to create new knowledge for solving the problems of the customers. Alliances in Europe have already been formed in some extent, but from them the European tool making industry could find even more strength.

Also virtual companies were offered as a solution for the same problem in chapter 5.3.4 (Supply chain management). In this technique virtual companies would by the services from other companies instead of forming a platform of partnerships. However, in collaboration platforms the partnerships would work both ways and give advantage to all the companies involved. For example a Finnish company could get maintenance services for their German customers from their German partner and vice versa. Collaboration platforms are a new invention and no ways have yet been developed to analyze them. Collaboration platforms need analyzing also, because creating a collaboration platform means that the business model changes on BM innovation level (see 4.3.2 and Picture 4.5).How to analyze platforms?

Platforms and networks have been discussed already for one decade. If the research group decides to concentrate on developing an analysis model for the collaboration platforms of tool making industry, it should read into the researches and articles written about networks or platforms. In the given time the writer of this research report could not orientate herself in all of those texts.

7 RELIABILITY ANALYSIS

The theoretic goal was to find all the methods that are available. In practice however, it is not possible to read all the researches, books, and articles written about this topic in a few months, so something can be, and probably is missing. But a bunch of methods, that can be used and are used in the tool making industry for analyzing, developing, implementing, and managing business and operations, were found. The fact that the writer has some experience in different industries increases the reliability of this research report. The fact that the researcher is young gives the research report a certain flavor: it is a vision of a young researcher. The things that she finds important have been highlighted and brought up in this report for the other researchers and the science community to see. Some information that was in contradiction with other similar information was found. In this kind of situations it can be impossible to know who is right. It can also be that both writers are right, but in different situations, like with quality problems. Heizer and Render (1999, p. 83) claim that 85 % of quality problems have to do with materials and processes where Deming (Hill 2000, p. 313 according to Deming 1986) claims that 85 % of failures can be traced to management. What has been written in this report is meant to be evaluated with criticism and even disproved, if solid arguments are found. The tasks of the research group are to shape these views forward according to their own targets.

For increasing the reliability and for ensuring the right direction of the research report it was given to the members of the research group and to one outside reader for feedback and comments. There was no feedback from the research group. From the feedback of the outside reader the logic of the report was improved and the reliability was enriched with a new point of view. A way for increasing the reliability of the research report could have been discussing with representatives of the tool making industry, but the limited time did not enable this. In the point of view of the research group the reliability of this report would have increased with better communication and cooperation inside the group. Especially quick feedback from the earlier versions of the report would have been valuable in the writing process.

The research results, especially in chapter five are transferable into all kinds of companies with production. Especially operational managers can benefit from the tools and techniques for analyzing, managing, developing and implementing operations in their everyday duties.

REFERENCES

Auerbach, M., Imtiaz, A., BaalsrudHauge, J. 2006.Collaboration within tool and die making industry through open-source ERP-solution with integrated CRM-functionalities. Research Institute for Operations Management (FIR) at Aachen University of Technology and Bremer Institut für Betriebstechnik und angewandte Arbeitswissenschaf. 8 p.[Cited 7/6/2011] Available at: http://www.ve-forum.org/projects/408/ICE%202006/Virtual%20Enterprises%20(Planning)/p17-46.pdf

Boer, H., Koch, C., Rytter, N. 2007. Conceptualizing operations strategy processes. International Journal of Operations & Production Management [e-journal]. Vol. 27, Iss: 10, pp. 1093-1114. [Cited 27/4/2011] Available at: http://www.emeraldinsight.com/products/journals/journals.htm?id=ijopm

Brown, S., Lamming, R., Bessant, J., Jones, P. 2000. Strategic Operations Management.Oxford, Butterworth-Heineman.286 p.

Cantrell, S., Linder, J. 2001.Five Business-model myths that hold companies back. Strategy & Leadership [e-journal]. Vol. 29, Iss: 6, pp. 13-18. [Cited 27/4/2011] Available at: http://www.emeraldinsight.com/journals.htm?articleid=872822&show=abstract

Cantrell, S., Linder, J. 2000.Changing Business Models: Surveying the Landscape. Accenture, Institute for Strategic Change. May 24, 2000. [Cited 3/5/2011] Available at: http://www.mendeley.com/research/changing-business-models-surveying-the-landscape/

Chang, H.,Luo, C. 2010. Analyze innovation strategy of technical-intensive industries: scenario analysis viewpoint. Business Strategy Series [e-journal]. Vol. 11 Iss: 5, pp.302 – 307. [Cited 14/7/2011] Available at: http://www.emeraldinsight.com/journals.htm?articleid=1881647&show=abstract

Charles Sturt University, Department of Education and Training [WWW]. [Cited 14/4/2011] Available at: http://hsc.csu.edu.au/metals_engineering/careers/2341/Toolmaker.html

Copperhill International, a consulting company [WWW]. Yritysanalyysi. 2006. [Cited 27/6/2011] Available at: http://www.copperhill.biz/Suomi/html_files/yritystutkimus.php

Fuller-Love, N.,Midmore, P., Thomas, D., Henley, A. 2006.Entrepreneurship and rural economic development: a scenario analysis approach. International Journal of Entrepreneurial Behaviour& Research [e-journal]. Vol. 12 Iss: 5, pp.289 – 305. [Cited 14/7/2011] Available at: http://www.emeraldinsight.com/journals.htm?articleid=1567384&show=abstract

Gino, F. Pisano, G. 2008. Toward a Theory of Behavioral Operations.Manufacturing& Service
Operations Management [e-journal].Vol. 10, Iss: 4, pp. 676-691. [Cited 20/4/2011] Available at:
http://msom.journal.informs.org/

Goh, M., Tay, G. 1995.Implementing a quality maintenance system in a military organization. International Journal of Quality & Reliability Management [e-journal]. Vol. 12 Iss: 4, pp.26 – 39. [Cited 17/6/2011] Available at:
http://www.emeraldinsight.com/journals.htm?articleid=840162&show=html

Heizer, J. Render, B. 1999. Operations Management. 5th edition. New Jersey, A Simon & Schuster Company. 835 p.

Hill, T. 2000. Operations Management – Strategic Context and Managerial Analysis.London, Macmillan Press LTD. 704 p.

Ho, W., Xu, X., Dey, P. 2010. Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. European Journal of Operational Research [e-journal]. Vol. 202, Iss: 1, pp. 16-24. [Cited 17/6/2011] Available at:
http://www.sciencedirect.com/science/article/pii/S0377221709003403

Huckman, R. 2009. Are You Having Trouble Keeping Your Operations Focused? Harvard Business Review [e-journal]. Vol. 87, Iss: 9, pp. 90-95. [Cited 18/5/2011]Available at: http://web.ebscohost.com

Hämäläinen, M. 2010. Index uskoo autoihin. Tekniikka&Talous.Iss: 10. [Cited 7/6/2011] Available at:
http://www.tekniikkatalous.fi/metalli/metallitekniikka/article531155.ece

Johnson, M., Christensen, C., Kagermann, H. 2008.Reinventing your business model. Harvard Business Review [e-journal]. Vol. 86, Iss: 12, pp. 50-59. [Cited 13/7/2011] Available at: http://hbr.org/2008/12/reinventing-your-business-model/ib

Kaplan, R., Norton, D. 1992. The balanced scorecard – measures that drive performance. Harvard Business Review [e-journal]. January-February, pp. 71-79. [Cited 20/5/2011] Available at:
http://www.stevenstech.edu/MSISCourses/450/Articles/ValueOfIT/TheBalancedScoreCard.pdf

Kaplan, R., Norton, D. 1996. Using the Balanced Scorecard as a Strategic Management System.Harvard business review's Must-Reads on strategy, [e-journal]. pp. 95-109. [Cited
9/6/2011] Available at:
http://www.mktgsensei.com/AMAE/Strategy/HBR%20on%20Strategy.pdf

Krishna, G., Palepu, P., Healy, M. 2008. Business Analysis & Valuation: Using Financial Statements. 4th Edition. Canada, Thomson Learning. [Cited 29/6/2011] Available at:http://books.google.com/books?hl=fi&lr=&id=azRz5iJV4eUC&oi=fnd&pg=PR3&dq=Business+analysis+using+financial+statement+data&ots=yTBBgnLEzp&sig=XUdOsQqkxT_tvCcBSSvmNxI9ITA#v=onepage&q=Business%20analysis%20using%20financial%20statement%20data&f=false

Lechner, C., Müller-Stewens, G. 2005. Strategisches Management – Wie Strategische Initiativen zum Wandel Führen. 3rd Edition. Stuttgart,Schäffer-PoescherVerlag. 786 p.

Leenders, M., Fearon, H., Flynn A., Johnson, P. 2002. Purchasing and supply management. 12thEdition.Boston, McGraw-Hill.743 p.

Lewis, M. 2003. Analysing organizational competence: implications for the management of operations. International Journal of Operations & Production Management [e-journal]. Vol. 23, Iss: 7, pp. 731-756. [Cited 20/4/2011] Available at:
http://www.emeraldinsight.com/products/journals/journals.htm?id=ijopm

Manninen, L. 2011. Mehut pihalle! Ovatko nämä pahimmat työvuorot? Taloussanomat [Magazine] 14.6.2011. [Cited at 14/6/2011] Available at:
http://www.taloussanomat.fi/tyo-ja-koulutus/2011/06/14/mehut-pihalle-ovatko-nama-pahimmat-tyovuorot/20118342/139

Neilson, G., Martin, K., Powers, E. 2008. The Secrets to Successful Strategy Execution.Harvard business review's Must-Reads on strategy, [e-journal]. June, pp. 81-94. [Cited 8/6/2011] Available at:
http://www.mktgsensei.com/AMAE/Strategy/HBR%20on%20Strategy.pdf

Osterling, M. 2009. Value stream mapping [Presentation].Osterling Consulting.[Cited 17/5/2011].Avaolable at: http://www.leanconstruction.org/lcissocal/VSM5-28-2009.pdf

PK-RH® Pk-yrityksen riskienhallinta. Liiketoiminnan nelikenttäanalyysi SWOT. Copyright © 2000-2009 VTT. [Cited18/5/2011]Available at:
http://www.pk-rh.fi/riskilajit/liikeriskit/liiketoiminnan-nelikenttaanalyysi-swot

Porter, M. 1979. The Five Competitive Forces That Shape Strategy. Harvard business review's Must-Reads on strategy, edited in 2008 [e-journal]. January, pp. 23-41. [Cited

18/5/2011] Available at:
http://www.mktgsensei.com/AMAE/Strategy/HBR%20on%20Strategy.pdf

Porter, M. 1996. What Is Strategy. Harvard business review's Must-Reads on strategy, 2008 [e-journal]. November-December, pp. 2-22. [Cited 21/5/2011] Available at:
http://www.mktgsensei.com/AMAE/Strategy/HBR%20on%20Strategy.pdf

Portland State University School of Business Administration. Operations Management, Process Strategy and Capacity Planning, Class 5. [Cited 20/6/2011] Available at:
http://www.sba.pdx.edu/faculty/scottc/day5/sld001.htm

Ruohotie, P. 2000. Oppiminen ja ammatillinen kasvu. Porvoo, WSOY.

Schittny, B. Methodik zur kontinuierlichen Überprüfung und Gestaltung der Wertschöpfungs-konfiguration im Werkzeugbau. 2011. Aachen, Werkzeugmaschinenlabor RWTH Aachen. Unpublished presentation. 16 p.

Schuh, G., Völker, M., Wolfgang, B. 2010. Collaboration platforms to enable global service provision in the tooling industry.German Academic Society for Production Engineering [WWW]. [Cited 6/6/2011] Available at:
http://www.springerlink.com/content/4207w875003r2717/fulltext.pdf

Slack, N. & Lewis, M. 2011.Operations Strategy.3rd Edition.British Library Cataloguing.in-Publication Data. 434p.

Summers, M. 1998.Analyzing Operations in Business: Issues, Tools & Techniques.Westport, CT, USA, Greenwood Press.235 p.

Tan, K., Matthews, R. 2009. Operations Strategy in Action – A Guide to the Theory and Practice of Implementation.Chelteham, Edwar Elgar Publishing Limited. 223 p.

Trends e-magazine.Business Model Innovation Becomes the New Strategic Focus.June 2010, Iss. 86, pp. 4-10. [Cited 15/5/2011] Available at:
http://www.trends-magazine.com/trend.php/Trend/2161/Category/49

Tutor2u. Product portfolio strategy – Introduction to the Boston Consulting box. [e-learning] [Cited 17/5/2011] Available at:
http://tutor2u.net/business/strategy/bcg_box.htm

United States Department of Labor, Bureau of Labor Statistics.Occupational Outlook Handbook. 2010-11 Edition. [Cited 6/6/2011] Available at:
http://www.bls.gov/oco/ocos225.htm

Walters, D. 2002.Operations Strategy. Hampshire, Palgrave Macmillan. 390 p.

APPENDIX 1: THE METHODS CHART

What?	How to plan?	How to implement?	How to analyze?	How to develop?
Strategy	Strategic positioning - choosing unique activities and trade-offs	Neilson et al.: decision rights, information, motivators, structure	Porter's 5 forces help to understand the industry	
			Balanced scorecard: financial and other measures, can also be used as a strategic management tool	
			Strategyaudit ???	
Business			Using financial statement data (Krishna et al.)	
			Analyzing products, production and human resources (Copperhill)	
			SWOT	
			Scenarioanalysis	
Business model	Lechner and Müller-Stewens			Changemodels
				BM innovation
Environment: markets, customers, laws and others that can affect companies			5 forces	
Operationsstrategy	Strategic operations (Walters)			
Operations in general		Considering 5 dimensions (Boer et al.), and knowing what problems there might be		
		4 elements (Slack& Lewis)		
		Who is responsible (Slack & Lewis)		
Quality	Meetingcustomerexpectations	Deming, Juran, Crosby	Cost of quality (Juran)	Identify causes of below sta quality
	Which dimensions should be checked, when, where and how?	Total quality management: continuous improvement, employee empowerment, benchmarking, just-in-time, knowledge of TQM tools	Check lists: where problems occur?	Taguchi technique, solving q related problems
	Quality function depoyment, house of quality	Lean	Scatter diagram: why defects happen?	Paretocharts, organizeerrors
		six sigma		Cause-and-effect diagrams, possible causes for problem
		Sampling, testingrandomsamples		Business processreengineeri
Products	Modularity		Portfolio technique: finding new product opportunities and analyzing which products to cut	

			Value analysis: reducing-costs	
Processes		Eight step plan from complete ignorance to complete knowledge for managers	Value strem mapping: cutting activities that don't create value	
			Flowdiagram: analyzing-processes	Flowdiagram: developingpro
			Processcharts: analy-zingprocesses	Processcharts: developingpr
			Time-function mapping: analyzing processes	Time-function mapping: dev processes
				Processreeangineering
Human resources	dealing with stability	Communicating	Behavioraloperations	Qualitycircles
	job design	Suggestion schemes		Teambuilding
		Continuousimprovement		Encouraging for non-work re hobbies
Supply chain	Make-or-buy?	Supplier selection: nego-tiation	Supplier selection: eva-luation	Supplier selection: developn
			Multi-criteria decision making approaches	
Inventory	Make to order	Continuousreview	ABC analysis	ABC analysis
	Economicorderquanti-ty	Periodicreview	The principle of depen-dent and independent demand	The principle of dependent a independent demand
		Single-bin / two-bin systems	Causalanalysis	Causalanalysis
		Accurate inventory record: using results of ABC		
Scheduling	Long-range, interme-diate-range, short-range		Senarioanalysis	
	Capacityplanning		Forecasting	
Maintenence	Priorityorder	Preventive and break-downmaintenance	Meantimebetweenfailu-res	
	Total productivemain-tenance	Conditionbasedmain-tenance		
		Stand-byequipment		
		Correctivemaintenance		
		Equipmentupgrades		
		Group replacement		
Improvingoperations	Continuous and breakthroughimpro-vement		Importance-performancemapping	Benchmarking
			Why-whyreviews	The sandconetheory
				The Demingcycle